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The FAA Airfield Capacity Model, a computer program designed to quickly calculate the runway capacity of an airport, has recently been upgraded.

Several new features have been implemented in the upgraded version. Among these are improved input and output formats for easier usage, the capability to compute runway capacity for up to eleven different percentages of arrivals in a single run (as opposed to a separate run for each percentage), and provisions for calculating the capacity of alternating arrivals to a pair of parallel runways. Several other runway configurations have been added to the model, or improved, as well.

This model users manual presents detailed instructions for using the FAA capacity and delay models. The manual is written primarily for airport planners and engineers who have a general familiarity with computer operations and who wish to apply these models to airport studies.

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16. Abstract

The FAA has developed a family of computer models for the analyses of the airside of an airport. These models can be used to determine the capacity and delay on airports, and to study the fine-grain sensitivity of capacity and delay to variations of airport specific conditions.

This model users manual presents detailed instructions for using the FAA capacity and delay models. The manual is written primarily for airport planners and engineers who have a general familiarity with computer operations and who wish to apply these models to airport studies.

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16. Abstract

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Several new features have been implemented in the upgraded version. Among these are improved input and output formats for easier usage, the capability to compute runway capacity for up to eleven different percentages of arrivals in a single run (as opposed to a separate run for each percentage), and provisions for calculating the capacity of alternating arrivals to a pair of parallel runways. Several other runway configurations have been added to the model, or improved, as well.

Other changes have been made to the internal logic of the model which will result in reduced running times and/or improved accuracy. The resulting capacities may, therefore, differ from the results obtained with the previous version. In most cases this will not affect the ranking of the potential airfield changes under evaluation.

This report documents the upgraded FAA Airfield Capacity Model. Volume I, "Supplemental User's Guide," provides a general overview of the major changes that have been made to the program and includes revised versions of the relevant chapters in the existing User's Manual, FAA-RD-76-128, "Model Users' Manual for Airfield Capacity and Delay Models." Volume I may also be used by itself as a guide to the input and output requirements of the upgraded model.

Volume II is a detailed technical description of the revisions to the program, including flow charts of the logic and evaluations of various alternative logics.

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UPGRADED FAA AIRFIELD CAPACITY MODEL

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NOTICE

PREFACE

This report was prepared by the Systems Research and Development Service of the Federal Aviation Administration as part of its broad research program to develop new and improved methods for determining how to increase capacity and minimize congestion on the airfield.

The purpose of this report is to furnish the aviation community with non-proprietary tools to determine airport capacity and delay. The author would appreciate receiving any comments pertaining to the use of this report.

The material contained in this report is based in part on the joint efforts of a project team headed by Douglas Aircraft Company and included Peat, Marwick, Mitchell & Co. (PMM&Co.); McDonnell Douglas Automation Company (MCAUTO); and American Airlines, Inc. Professor Robert Horonjeff of the University of California, Berkeley, served as general advisor to the project team.

As part of the coordinated efforts of the Project Team each organization carried out specific responsibilities, as summarized below:

ORGANIZATION	Project Responsibility
DAC	Prime Contractor; overall technical d[illegible]ction and project management; [illegible] collection support; on-line capacity.
PMM & CO.	Capacity and delay model development; report development; management of data collection and analysis; software review modification and development; training.
McAUTO	Interactive Graphics system and real time simulator feasibility studies; delay model air traffic control algorithm; model software development; data processing; software documentation; training.
AAL	General advisory, overall project.
MITRE	Upgraded the runway capacity programs to provide simplified input, more complete output, and to add additional program options--alternating arrivals to parallel runways. Program logic has also been modified to produce more consistent and more accurate results with reduced running times.

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1. INTRODUCTION

1.1 Description of the Model

The FAA Airfield Capacity Model is a computer program which analytically calculates the maximum operational capacity of a runway system under a wide range of conditions. The user has considerable freedom to vary the characteristics of the runway, aircraft, and ATC system.

The capacity model was originally developed in the early 1970s by a consortium which included Peat, Marwick, Mitchell and Company (PMM&Co.) and McDonnell Douglas Automation (MCAUTO). The program was further modified by the Systems Research and Development Service (SRDS) branch of the FAA. The model has been used by the FAA for the Airport Capacity and Delay Task Force studies, and is currently available to the public through the Control Data Corporation (CDC) timesharing computer service. It is this SRDS version which will be referred to in this report as the "original" version of the program, since it was the basis for the upgraded version described herein.

A major effort to upgrade the capacity model has been concluded. Modifications to the program focused on three principal areas:

- adding new functions and abilities
- updating to incorporate the latest ATC procedures
- correcting minor program errors.

1.2 Description of the Documentation

This report constitutes Volume I of a two-volume set of documentation on the upgraded capacity model. Volume I, the Supplemental User's Guide, includes a brief, non-technical description of the principal changes to the program (Section 2) and a summary of changes to the model input and output (Section 3). In addition, two appendices contain revised versions of the chapters in the original User's Manual (FAA-RD-76-128, Reference 1) which pertain to the Airfield Capacity Model.

Volume II of the documentation is a technical description of the modifications which have been made to the Airfield Capacity Model. This report describes, in detail, the original model logic and the process by which the improvements to the model were developed, tested, evaluated and implemented.

Comparisons are presented for the capacity results and running costs of the original and the upgraded versions of the Capacity Model.

Several topics which should be contained in the full documentation of the Airfield Capacity Model will not be fully discussed in the present report. These include:

- a separate list of all the assumptions in the model
- default values for all parameters
- sources of input data
- discussion of techniques for effective use of the model.

It is hoped that these and other such areas will be included in any future revision of the User's Manual.

2. MODEL CHANGES AFFECTING THE USER

This section briefly describes the more significant model modifications and the way in which they affect the user. Many of these features are optional capabilities that the user should be aware of, to use if he so wishes. Appendices A and B will give more details on how to implement these options.

The model changes are divided into two categories: those which affect all runway configurations, and those which affect only particular configurations.

2.1 General Changes

2.1.1 Multiple Arrival Percentages

The FAA Airfield Capacity Model calculates capacity at a given arrival percentage by first calculating an arrival-priority capacity (maximum number of arrivals plus whatever departures are possible) and a departure-priority capacity (similarly, the maximum number of departures). It then interpolates between these points, or drops the excess arrivals or departures, to reach the desired arrival percentage.

In the original version, only one arrival percentage could be specified per run. If the capacities at several arrival percentages were desired, several runs would have to be made; the same arrival-priority and departure-priority capacity values would be calculated each time, but the details of the interpolation would differ. Calculating these capacity values is much more expensive than interpolating between them. In the upgraded version, up to 11 different arrival percentages can be specified during a single run (on the OTHERS line, line 20 of the input file -- see Appendix A), saving the expense of recalculating the arrival-priority and departure-priority capacities.

In the original version, an arrival percentage of "9999" would result in the output of the arrival-priority capacity values. The upgraded version will, in addition, output the departure-priority capacity values if the arrival percentage is "8888."

2.1.2 Gap Stretching

When the arrival priority capacity is calculated, the maximum number of arrivals are generated first, and departures are fitted into the resulting gaps as feasible. It would seem likely that certain gaps could be "almost large enough" to fit an additional departure into, and that additional departure capacity could thus be gained by "stretching" these gaps slightly.

There is a great deal of difficulty, however, in determining which gaps to stretch and by how much to stretch them, primarily because we are dealing with a probable number of departures per gap, rather than a deterministic number. (In other words, stretching a specific gap between two individual arrivals may increase the number of departures in that gap from 1 to 2, but stretching all the gaps between those two arrival types might only increase the average number of departures per gap from 1.8 to 1.9.) The revised program operates by stretching all gaps, at least initially, by a pre-specified increment, but retaining the stretch only when there is a capacity benefit.

Capacity is first calculated for the (unstretched) arrival-priority case. Next, each gap is stretched by the increment "x." The expected number of departures in each gap is then calculated. If there is no benefit to the gap stretch, the gap is returned to its unstretched size. Arrival and departure capacities are then recalculated, given the remaining stretched gaps. The resulting capacity is referred to as the first intermediate point on the capacity curve.

For the second intermediate point, each gap is stretched by twice the increment, relative to its unstretched size, and the testing is repeated.

The user can specify both the maximum number of intermediate points and the gap-stretching increment in the INCIAT line, line 26. If these values are not specified, the program defaults to one intermediate point with a maximum gap stretch of 20 seconds. If an arrival percentage of "7777" is specified, the capacity at each intermediate point will be output.

2.1.3 Deletion of the Equal-Priority Models

The original version of the Capacity Model had an option available for calculating capacity at 50% arrivals. Arrivals and departures were given equal priority in runway use and strict alternation of arrivals and departures was enforced. This meant that some arrival gaps would be stretched to accommodate a single departure, while another gap which was large enough for two or more departures without stretching might have unused capacity. This type of inefficiency resulted, in some cases, in an "equal-priority" capacity which was less than that obtained by running arrival-priority for part of the hour and departure-priority for the remainder (i.e., interpolation between the two values).

The equal-priority logic has been removed from the upgraded Capacity Model. It was felt that the gap stretching procedure described in the previous section provides a better means of calculating capacity at 50% arrivals. Strict alternation of arrivals and departures is no longer enforced, but the overall balance between arrivals and departures is preserved.

2.1.4 First Enqueued Departure Mix

In computing the capacity of a mixed-mode (arrivals and departures) runway, the departure capacity is based upon the most limiting aircraft type. In this way the specified fleet mix is preserved.

The original program logic assumes that the probability that a particular aircraft type is the first departure in an arrival gap is the same as that type's proportion of the overall aircraft mix. In reality, this probability is also affected by the difficulty with which each departure type can be inserted into the previous gap. In other words, if a departure does not fit into the current gap, it will be first in line to depart in the next gap. The original program logic, on the other hand, would in effect make that aircraft go back to the end of the departure queue.

The "first enqueued departure" (f.e.d.) mix logic that has been added to the program recognizes explicitly that aircraft do not show up at random to be first in line to depart. The f.e.d. mix is calculated iteratively, since changing the mix for the first departure changes the probability of getting out the second and third departures, which in turn affects the mix for the first departure in the next gap. However, the f.e.d. mix converges rapidly. The user can specify both the maximum number of iterations and the convergence criterion to be applied (INCIAT, line 26).

2.1.5 Separate Probability of Violation for Interarrival Times

Several steps in the model logic call for the calculation of a buffer time which is then added to a nominal event time. For example, a 5% buffer is added to average runway occupancy time to derive a "protected occupancy time" which is used for planning purposes. This 5% probability of violation (PV) may be interpreted as meaning that only 5% of all occupancy times will be greater than the "protected time."

A buffer is also added to minimum interarrival time (the time between arrivals at the threshold based on minimum separations) to derive an average interarrival time. For the present day ATC system, this is also a 5% buffer, which in this case means that

only 5% of all interarrival times would be below the minimum inter-arrival time. In the future, however, metering and spacing will be automated, and a 1% buffer will be used. A lower probability of violation is required because it is desirable to limit the number of times a human controller must step in to resolve the violations.

The original program used just a single PV, and therefore could not handle the case of a 5% buffer on runway occupancy and a 1% buffer on interarrival time. Two PVs can be specified in the upgraded program, one for interarrival time and one for all other applications. These are input on the revised OTHERS line, line 20.

2.2 Configuration - Specific Changes

The following model modifications apply only to certain runway configurations.

2.2.1 Single Runway - Optional Use of "Q-Logic"

ATC procedures require that certain separations be applied between consecutive departures, for conflict- and vortex-avoidance. These separations must be applied even if there is an intervening arrival.

It is a simple matter to consider the effect of these departure-departure separations within a given arrival gap, but considerably more difficult to account for their effect between gaps. This is because we now must consider the aircraft type of the last departure in the previous gap and its position within that gap, which in turn depends upon the size of that gap and the other departures within that gap. The logic used in the model for considering the effect between gaps deals with probabilities for the aircraft type, the position within the previous gap, and the effect on departures in the current gap. We refer to this as the "Q-logic," since Q is a unique variable used therein.

In the original model version, the Q-logic is used only for the close parallel (dual-lane) and intersecting runway cases. It was not felt to be needed for the single runway, because the normal separation between departures in different gaps is usually greater than the separation requirement (the first departure must clear the runway before the arrival lands, and then the arrival must clear before the next departure can be released -- with buffers, the time between departures would be about 100 seconds). However, since 120 seconds is required for a non-heavy departure behind a heavy departure, it is possible for the previous departure to affect the departures in the current gap.

It has therefore been left up to the user to decide whether or not to use the Q-logic with a single runway. An arbitrary negative value for DIAGSP, on the ALTARR line (line 25), is used to implement the single-runway Q-logic. In most cases, the effect will be quite small.

2.2.2 Parallel Runways - Alternating Arrivals

The latest version of the ATC procedures (Handbook 7110.65B, Reference 2) allows the operation of dependent arrivals to parallel runways with a 2.0 nmi separation applied diagonally between consecutive arrivals. The normal longitudinal separations still apply between consecutive arrivals to the same runway. A subroutine has been added to the program to calculate capacity with alternating arrivals.

It is necessary to consider a set of four alternating arrivals to determine the spacing between two arrivals to the same runway. For example, aircraft A is a heavy aircraft (> 300,000 lbs.) landing on runway 1 (Figure 2-1). Aircraft B, a "small" bound for runway 2, is 2.0 nmi diagonally behind A. C, a "large" aircraft, is 5.0 nmi behind A on runway 1 because of intrail vortex requirements. The next arrival to runway 2 would be 2.0 nmi diagonally behind C, and therefore 5.0 nmi behind B, a small aircraft which would normally require only a 3.0 nmi separation or less. When the spacing between B and D is determined by the separation between A and C, we refer to this as "shadow spacing."

"Shadow spacing" can also result from speed differentials between aircraft or other constraints. The new subroutine deals with "shadow spacing" by selecting a set of four aircraft, and then calculating the earliest time for each aircraft to cross the threshold, subject to the constraints of

- separation from previous arrival, same runway
- separation from previous arrival, other runway
- time to fly from gate to threshold
- runway occupancy time, previous arrival.

The subroutine also accounts for runway thresholds or approach gates which are displaced relative to each other.

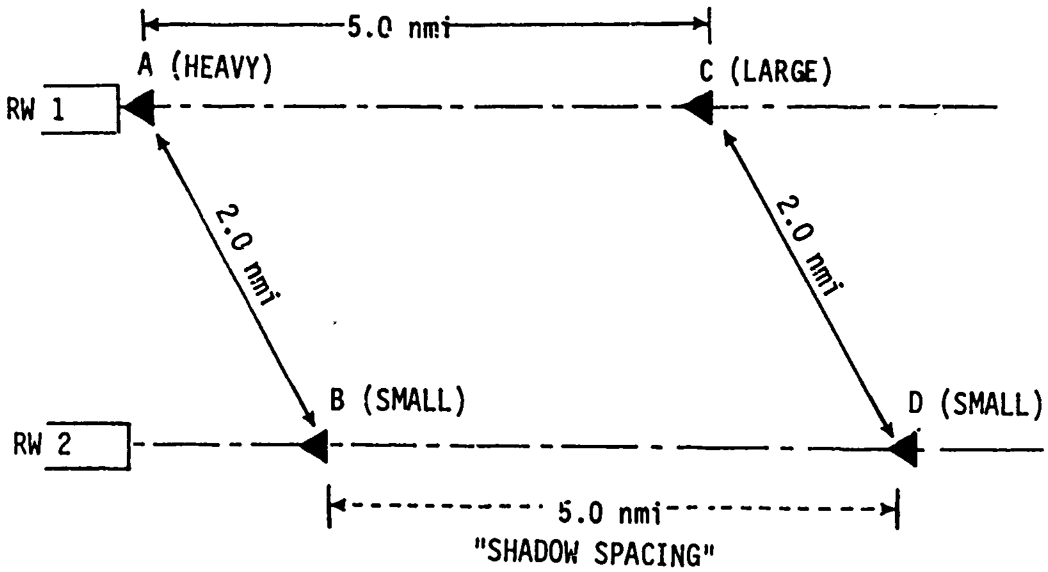


FIGURE 2-1
ILLUSTRATION OF "SHADOW SPACING"

2.2.3 Intersecting Runways - New Configurations Added

Only two configurations of two intersecting runways were available in the original program -- arrivals on one, departures on the other, and mixed on one, departures on the other. The latter configuration implies that departures can be run on both runways, but such a configuration was not available by itself.

The revised program now includes such an option (configuration 6-1, runway diagram number 52). Operationally, this configuration is similar to alternating arrivals -- the interval between departures depends not only on the required separation between aircraft on the same runway, but also on the separation needed at the intersection behind an aircraft on the other runway, due to wake vortices. Consequently, a similar logic is used. A set of four departure aircraft is selected, and the earliest release time is generated for each, based on the relevant constraints.

If more capacity can be achieved by operating departures on just a single runway, this single-runway capacity will be returned by the program, along with the message, "ALL DEPARTURES ARE ON SINGLE RUNWAY."

2.2.4 Complex Configurations

"Complex configurations" are, in general, those with more than two runways. They are treated in the program as combinations or special cases of the simple configurations -- single runway, two parallel, or two intersecting runways.

Two aspects of this handling of complex configurations were open to question: the simplification of complex configurations in full IFR conditions (formerly called PVC), and the calculation of the departure-priority capacity of complex configurations. Full IFR conditions, with full applications of IFR rules, were rarely considered; for example, departures and arrivals on separate close-spaced parallel runways were considered to be independent, contrary to IFR rules.

Details of the revised treatment of complex configurations are presented in Appendix D of Volume II.

3. CHANGES TO INPUT/OUTPUT

In addition to the changes to the program logic itself, numerous revisions were made to the program input and output. Some of the revisions were necessitated by the changes to the program logic: input data required for the new program functions, for example. Other input changes resulted from the deletion of certain program functions which are no longer used. Program output was revised to make it more readily usable.

Input data to the program may be provided in either of two ways: interactively or in input file form. In the interactive mode, the program asks specific questions about the case to be run (aircraft mix, runway configuration, etc.) and uses the results to construct an input file containing all necessary data for a single run. The resulting input file may be saved for future runs.

In the input file (batch) mode, input data is contained in a separate data file or, perhaps, a deck of cards (depending on the manner in which the program is implemented). This data file may have been created directly by terminal entry; interactively, as described above; or incrementally, by modifying a pre-existing input file. Regardless of the procedure used, the batch mode presents several advantages, including fuller control over the input values and the ability to model several different cases with a single run.

In the following sections, the principal changes to program input and output will be briefly described. More complete descriptions will be found in Appendices A and B, the substitute chapters for the User's Manual. The general form of the input and output have been maintained, but a sufficient number of details have been changed that input files for the original program version will not work for the upgraded version.

3.1 Interactive Input

The interactive capability of the FAA Airfield Capacity Model permits any user to calculate capacities without requiring a detailed knowledge of the program. The program asks the user a series of questions about the runway configuration, ATC system, and aircraft fleet, and uses the answers to construct an input file for the capacity program. For subsequent runs, the input file can be saved and edited, or else the program can be rerun interactively.

Appendix B of this report will present each question asked by the program (in both long and short form), and will discuss the nature and format of the answers expected from the user. All these questions would not appear in any single run, because certain questions are dependent upon the answers to previous questions. To give two examples, some questions will be asked only if a parallel runway configuration has been specified, others only if an intersecting configuration is to be analyzed.

The following are some of the principal changes which were made to the interactive mode of the program.

3.1.1 Standard ATC Scenarios

The number of standard ATC scenarios has been reduced to four: present, near-term, intermediate-term, and far-term. These scenarios are described in Table 3-1, which shows the explanatory message printed out by the Capacity Model in the interactive mode. Each "scenario" represents a pre-stored file of arrival-arrival and departure-departure separations, metering and spacing parameters, and maximum runway occupancy times (for future scenarios). These values have been obtained from FAA-EM-78-8A, "Parameters of Future ATC Systems Relating to Airport Capacity/Delay" (Reference 3).

3.1.2 Weather Conditions

The weather conditions recognized by the program have been renamed to reduce some confusion. They are now

- VMC -- Visual Meteorological Conditions
- MMC -- Marginal Meteorological Conditions
- IMC -- Instrument Meteorological Conditions.

These conditions are explained in Table 3-2.

3.1.3 Alternating Approaches

As described in Section 2.2.2, the program can now calculate the capacity for alternating parallel arrivals with a specified diagonal separation. The interactive mode has been modified to request the necessary data for the calculation. If a parallel runway configuration has been specified and the distance between runways is more than 3000 feet, the program will ask "RUN ALTERNATING APPROACHES?" If the answer is YES, the next question will request the diagonal separation standard to apply and the amount of threshold stagger, if any.

TABLE 3-1

EXPLANATION OF ATC SYSTEM CODES

THE FOLLOWING ATC SCENARIOS REPRESENT FAA E & D PLANNING AS OF JANUARY, 1980, AS DESCRIBED IN FAA-EM-78-8A.

ATC CODE	TIME FRAME	DESCRIPTION
P	PRESENT	CURRENT ATC SYSTEM
N	NEAR-TERM	VAS, TERMINAL FLOW MANAGEMENT
I	INTERMEDIATE	WVAS, TERMINAL FLOW MANAGEMENT, REDUCED RUNWAY OCCUPANCY IN IMC
F	FAR-TERM	WVAS, ADVANCED TERMINAL FLOW MANAGEMENT FURTHER REDUCTIONS IN IMC RUNWAY OCCUPANCY

TABLE 3-2

EXPLANATION OF WEATHER CONDITIONS

WEATHER		VISIBILITY* (STAT. MI.)	CEILING* (FEET)	OPERATIONAL IMPACT
VMC	VISUAL METEOROLOGICAL CONDITIONS	5.0	5000	VISUAL APPROACHES -- PARALLEL RUNWAYS >700' APART ARE INDEPENDENT
MMC	MARGINAL METEOROLOGICAL CONDITIONS	2.5	900	IFR SEPARATIONS APPLY BETWEEN ARRIVALS -- PARALLEL RUNWAYS <4300' APART HAVE DEPENDENT ARRIVAL OPERATIONS -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS >700' APART ARE INDEPENDENT BECAUSE VISUAL SEPARATIONS ARE APPLIED
IMC	INSTRUMENT METEOROLOGICAL CONDITIONS	0.0	0	ALL IFR PROCEDURES ARE IN EFFECT -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS <2500' APART ARE DEPENDENT

*THESE ARE VALUES WHICH ARE INPUT TO THE PROGRAM, NOT BREAKPOINTS BETWEEN WEATHER CONDITIONS

3.1.4 Intersection Clearance Times

For intersecting runway configurations, the program asks for the distance from threshold to intersection for each runway. This is used to compute the time required for arrivals and departures to clear the intersection. Formerly a table look-up process, this calculation is now performed explicitly on the basis of

- constant acceleration for departures of 6 ft/s^2

- liftoff at 1.4 times the stall speed

- arrivals touch down 1500 ft from the threshold, then decelerate at 5.3 ft/s^2 to a runway taxiing speed of 60 kn.

These intersection clearance times are then used to compute the arrival/departure and departure/arrival separation requirements. If the aircraft are airborne at the intersection, this separation must account for the required vortex separation between aircraft at the intersection. For intersecting runway configurations, the interactive program asks specifically, "ARE AIRCRAFT AIRBORNE AT INTERSECTION?"

3.1.5 Arrival Percentages

As stated in Section 2.1.1, the program will now accept up to 11 values of arrival percentages in a single run. This is sufficient to allow the user to specify 0% to 100% by 10% increments.

The value to be input could also be one of three special values:

- 9999 -- the program prints the arrival-priority capacity values, regardless of the arrival percentage.

- 8888 -- the program prints the arrival-priority and departure-priority capacity values.

- 7777 -- the program prints these two sets of values plus as many intermediate points as have been specified. The program defaults to one intermediate point with a "stretch" of 20s.

These special values are valid only in the first position; elsewhere they are ignored. This is because they are not needed in other positions -- normal output mode includes printout of the

arrival-priority capacity values, plus the departure-priority values and whatever intermediate points were necessary to determine the capacity at the desired arrival percentage.

3.1.6 Average Runway Occupancy Times

The interactive program previously requested the location and tvpes of exits along the runway and used this information to compute the average runway occupancy times (using stored values). The upgraded program asks for these average times directly.

3.2 Batch Input

The capacity program obtains the information it needs on aircraft fleet mix, approach speeds, etc. from a fixed format input file.

Appendix A of this report will describe each line of the input file as it has been restructured for the upgraded Capacity Model. Some of the input lines have not changed, in either form or content, from what was required by the original version of the capacity program.

3.2.1 Line 0, NEWRUN

The third value on this line previously served as an indicator of whether or not to run the equal-priority model. Since the equal-priority models have been discontinued, this indicator is now used to signal the model to run alternating arrivals.

3.2.2 Line 2, ARBAR2

Input on this line now consists of 4 average runway occupancy times, one for each aircraft class, on a single line. Previously one line was used for each aircraft type; each line contained up to 11 values of runway occupancy, one for each runway exit. These values were then combined with the information on line 3, EXITPT (the percentage of use of each exit) to determine the overall average occupancy time, which is now input directly. Line 3, EXITPT, is no longer used.

3.2.3 Line 11, TWOIN

This line provides data used by some intersecting runway configurations. Two new input items on this line are:

- o a flag which indicates whether or not aircraft are airborne at the intersection

- o the average time for a departure to clear the intersection.

3.2.4 Lines 14 to 18

These lines are no longer used. They were originally associated with the gate and taxiway capacity models, which have been dropped from the program.

3.2.5 Line 19, SIGMAS, and Line 20, OTHERS

Line 19, SIGMAS, contains all the standard deviations used in the program. This data has been moved from line 20, OTHERS, in order to make room on that line for up to 11 different values of arrival percentage. The three special values of arrival percentage were discussed in Section 3.1.5.

3.2.6 Line 25, ALTARR

Information needed to run alternating arrivals with a diagonal separation standard has been grouped on this line. It includes

- o the diagonal separation standard
- o the separation between runway centerlines
- o the relative runway threshold displacement
- o the relative approach gate displacement.

3.2.7 Line 26, INCIAT

This line has been added to the input file to provide required information for the first-enqueued-departure logic (Section 2.1.4) and for the gap stretching logic (Section 2.1.2). This data includes:

- o the maximum number of iterations for the f.e.d. mix
- o the convergence criterion for the f.e.d. iterations
- o the maximum number of points for which arrival capacity is calculated (arrival-priority point plus the number of intermediate points)
- o the increment by which interarrival times are stretched.

3.3 Changes to the Output

Output format has been changed slightly, and some additional information is now printed out, in an attempt to make the output more useful. Figure 3-1 illustrates some of these changes with the output from a typical run.

Standard output now includes:

- o a description of the configuration being run
- o each capacity value (arrival-priority, departure-priority, and any intermediate points) used to calculate the capacity at the desired arrival percentage
- o for each intermediate point, the maximum value by which each gap might have been stretched (actual stretch for any gap might have been less, if the maximum stretch was not beneficial)
- o details of the procedure for achieving the desired arrival percentage (drop excess arrivals or departures, or operate part of the hour in one mode and the remainder in another).

For certain configurations, additional informational messages are printed. For example, for alternating arrivals with diagonal separation, the message "ALTERNATING APPROACHES --- x NMI DIAGONAL / y FT" will appear, where x is the diagonal separation and y is the separation between centerlines. If an intrail separation is used instead, the message is "ALTERNATING APPROACHES --- x NMI INTRAIL SEPARATION."

In other cases, the program evaluates capacity under two different operating strategies for the same configuration and chooses the strategy which maximizes capacity. A message will then be printed which identifies the preferable strategy. For example, two intersecting runways with departures on both may be run as two runways or with all departures on a single runway. In the latter case, the program outputs the message "-- ALL DEPARTURES ARE ON SINGLE RUNWAY."

Program output is also discussed in the appendices.

```
** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

NEWRUN 0 0 0
   6   2   0
RUNWAY 1 1 0
0.0 0.0 0.600.40
RUNWAY 2 1 0
0.0 0.0 0.600.40
ARUAR2 1 2 0
 34. 34. 42. 45.
DLTAIJ 0 4 0
 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.5 2.5 2.0 2.0 3.0 3.0 2.5 2.0
APPSPD 0 5 0
 95 120 130 140
DRDAR  0 6 0
  29  34  39  39
TD      0 7 0
  60  60  60  60  60  60  60  60  60  60  60  60  60  60  60  60
GAMA    0 8 0
   6   6   6   6
TGRDAR 0 9 0
 23. 22. 27. 27.
ADSR   112 0
  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.
DICDR  013 0
 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0
SIGMAS 019 0
  4.  8.  0.  0.  6.
OTHERS 020 0
0.050.01 2.0 0.0   0 3.00.0    50
INCIAT 026 1
   1.050   2 20.


TWO INTERSECTING, ARR ON #1, DEP ON #2

    ARRIVAL PRIORITY CAPACITY   (POINT #1)
              TOTAL =   90.10  ARRIVALS =  45.81     DEPARTURES =  44.30


    DEPARTURE PRIORITY CAPACITY
              TOTAL =   60.00  ARRIVALS =   0.0      DEPARTURES =  60.00


    CAPACITY AT POINT #  2                 MAX GAP STRETCH =  20. SEC
              TOTAL =   89.38  ARRIVALS =  43.17     DEPARTURES =  46.21

TO OBTAIN  50 PERCENT ARRIVALS, OPERATE
        .AT POINT   1 FOR  66 PERCENT OF THE HOUR, AND
         AT POINT   2 FOR  34 PERCENT


              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =    89.9  ARRIVALS =   44.9  DEPARTURES =   44.9


        *****     *****     *****     *****     *****     *****
```

FIGURE 3-1
EXAMPLE OF PROGRAM OUTPUT

CHAPTER 1 - INTRODUCTION

1.1 Purpose

The Federal Aviation Administration (FAA) has been involved for several years in a broad research program to develop reliable planning tools to evaluate proposed approaches to increasing capacity, minimizing congestion on the airfield, and to quantify changes to the airport airside system. This report introduces the results of an engineering and development project which applied advancements in computer technology and mathematical modeling to the determination of airfield capacity and aircraft delay. The purpose of this report is to describe in detail the preparation of inputs for the computer programs resulting from this project.

1.2 Background and Objectives

A graphical procedure for estimating runway capacity was developed for the FAA in the early 1960's. This procedure defined capacity in terms of an "acceptable" value of delay per operation; i.e., level of service definition of capacity. It did not permit detailed analysis of site specific conditions. Since its development, wide-body aircraft have been placed in service, new aircraft separation rules have evolved and the need to consider more runway use configurations has arisen. These factors coupled with current and anticipated congestion and delays at high-activity airports led to the need for more refined techniques for determining airport capacity and delay.

In June 1972, the FAA retained a project team to develop computer programs for predicting airfield system capacity and aircraft delay. The project team was headed by the Douglas Aircraft Company of the McDonnell Douglas Corporation and included Peat, Marwick, Mitchell & Co. (PMM&Co.); McDonnell Douglas Automation Company (MCAUTO); and, American Airlines, Inc. Professor Robert Horonjeff of the Institute of Transportation and Traffic Engineering (University of California, Berkeley) served as a general advisor to the project team. The objectives of the project team were:

a. To develop validated computer programs for determining airfield capacity and aircraft delay.

b. To prepare a report providing simplified procedures; i.e., curves, tables, etc., for determining hourly capacity and delay as well as annual capacity and delay for use by airport planners in both the FAA and industry.

In support of the project, a comprehensive data collection program was carried out. Some 150,000 items of data were collected at 18 U.S. airports. In addition, extensive data from other sources was used in the analysis. This data base was used to formulate the basic capacity and delay models, and to develop the operational parameters; i.e., arrival-arrival separations, runway occupancy time, approach velocity, etc., used to produce the simplified procedures to calculate airfield capacity and aircraft delay.

In consultation with FAA and industry users, the project team selected a definition of capacity which was independent of aircraft delay. It was determined that capacity defined as the upper limit or maximum number of aircraft operations that can occur would be a more natural and better understood concept. The selected approach to the definition of runway capacity has several advantages. It allows the sponsor/planner to select the level of service; i.e., average delay per operation, for which the airport will be designed (or will be permitted to operate). It also provides a realistic hourly limit to the operations rate for an airport. Recognizing the need to relate demand, capacity and delay in airport planning, the project team developed hourly delay curves which can be used to quickly approximate the average hourly delay per operation associated with airport specific capacity and schedule (i.e., demand and peaking within the hour) characteristics.

Airfield capacity and delay models were developed to analyze site specific airport conditions. They were validated at three high traffic volume airports.

- o Chicago-O'Hare International Airport (ORD)
- o Dallas Love Field (DAL)
- o Orange County Airport, Santa Ana, Ca. (SNA)

The validation process was performed to verify the logic and accuracy of the capacity and delay models. The validation demonstrated that the Capacity Model yielded aircraft flow rates and the Delay Simulation Model yields travel times well within the required contract accuracy of ± 15%.

In pursuing the above project, the FAA had two program objectives:

(1) To update and extend the present Advisory Circulars pertaining to airport capacity and delay.

(2) To develop computer programs to standardize the procedures used for detailed site specific analyses of airport capacity, delay and congestion.

Report FAA-RD-74-124 titled "Techniques for Determining Airport Airside Capacity and Delay," dated June, 1976, fulfilled the first program objective. The instructions provided in this report are a part of the fulfillment of the second.

1.3 Principal Definitions

The principal terms used in this report are:

a. Hourly Runway Capacity. Hourly runway capacity is defined as the maximum number of aircraft operations (i.e., arrivals and departures) that can take place on the runway(s) in an hour under a specified combination of conditions. The hourly runway capacity depends on a number of conditions including, but not limited to, the following:

(1) Runway Use Configuration

(2) Aircraft Mix

(3) Percent Arrival

(4) Percent Touch-and-Go

(5) Operating Conditions (VFR, IFR)

(6) Exit Location and Type

(7) Separation Between Aircraft

(8) Aircraft Operating Characteristics

The capacity values calculated using this report are the maximum flow rates that occur under saturation conditions. Capacity flow rates assume that arrival and/or departure aircraft are always available when needed to fill every operational slot. This situation would normally require that the queue of arrival or departure aircraft be at least one. The capacity flow rates make no arbitrary assumption regarding "acceptable" delay per operation. Delays at capacity flow rates may vary from 2 to 10 or more minutes per operation, depending on the distribution of demand over the hour (i.e., bunching) and the length of time that demand rates are greater than capacity.

For many applications the user will want to determine a runway flow rate that can be sustained for an extended number of hours during the day. In determining a sustainable flow rate, the capacity parameters must be carefully considered. It should not be assumed that an airport would operate at a flow rate equal to hourly capacity for several consecutive hours except under unusual or severe conditions, and then only with major delay problems.

b. Aircraft Delay. Aircraft delay is defined as the difference between the actual time it takes an aircraft to operate on the airport and the normal time it would take the aircraft to operate without interference from other aircraft. Conditions accounted for are:

(1) Inbound Arrival Holds; i.e., the additional flying time required of airborne arrivals due to instantaneous or prolonged periods of overdemand on the final approaches to the runways. Components of this delay are:

(a) Terminal Area Vectoring Delays

(b) Holding Stack Delays

(c) Enroute Path Stretching Delays

(2) Departure Queue Delays; i.e., the time a departure spends waiting for access to the runway whether the airplane is waiting in a queue or is taxiing at reduced velocities while awaiting access.

(3) Taxi-in and Taxi-out Delays; i.e., the time a taxiing aircraft has to wait at a taxiway intersection or is otherwise prevented from moving on a taxiway.

(4) Runway/Taxiway Crossing Delay; i.e., the time spent by a taxiing aircraft while holding to cross an active runway.

(5) Gate Delay; i.e., the time an aircraft has to wait due to a gate not being available or because it is prevented from backing out of its gate due to other taxiing aircraft.

The delay model described in this report does not (normally) account for delays due to enroute congestion, transitioning from one runway use configuration to another, or delays due to airport closures. Delays due to maintenance or construction can be calculated by properly applying the techniques; i.e., selecting the input data.

Aircraft delay is expressed in minutes per operation. The value obtained represents an average or expected value. Delays to individual aircraft may vary substantially from this average.

c. Deleted.

d. Deleted.

e. <u>Annual Service Volume</u>. Annual Service Volume is a measure of the annual capacity of an airport. Factors considered in determining Annual Service Volume include, but are not limited to:

(1) Level of service; i.e., average delay per aircraft

(2) Hourly demand peak

(3) Daily demand peak

(4) The adverse effect of low capacity periods

f. <u>Annual Delay</u>. Annual Delay is the total delay incurred by aircraft during a year. Factors considered in determining Annual Delay include, but are not limited to:

(1) Total annual demand

(2) Hourly distribution of annual demand

(3) Demand distribution within an hour

(4) Hourly capacity distribution

(5) Annual weather distribution

g. Runway Use Configuration. Runway use configuration is a term used to categorize specific combinations of airfield geometry and operational use.

The geometry includes:

(1) The number of runways in coordinated use. This identifies the unique combination of runways in use during some period of time.

(2) Relative orientation of the runways; i.e., single, parallel, intersecting, open V, etc.

(3) Separation; i.e., centerline separation, distance from threshold to intersection, etc.

The operational use includes:

(1) The direction of operation on the runway.

(2) The kind of operations taking place on each runway; i.e., arrival only, departure only, arrival and departure operations, and touch-and-go operations.

(3) Location of departure roll point; i.e., where on the runway do departures start from?

The definition of runway use configuration is further illustrated by the examples in paragraph 3.7.

h. Aircraft Mix. Aircraft mix is defined in terms of four aircraft classes: A, B, C, and D. In general, the aircraft (e.g., DC10, B727, B99, etc.) included in each aircraft class is at the users discretion. Exceptions to this general rule are noted in paragraphs 2.2.9 and 4.2.4. A recommended definition of aircraft classes is:

Class A - small single-engine aircraft weighing 12,500 lbs. or less;

Class B - small twin-engine aircraft weighing 12,500 lbs. or less and Lear Jets;

Class C - large aircraft weighing more than 12,500 lbs. and up to 300,000 lbs.;

Class D - heavy jet aircraft capable of gross takeoff weights of 300,000 pounds or more.

A list of typical aircraft in each class is presented in Figure 1-1.

The aircraft mix is expressed as the percentage of each aircraft class demand in the total demand; i.e., %A, %B, %C, %D.

i. Percent Arrival. Percent arrival is defined as the percent of all aircraft operations that are arrivals.

Arrival operations can be expected to average 50 percent over an extended period (usually 2 or more hours). However, operations are normally above or below 50 percent for shorter periods (30 minutes to an hour). The impact of high arrival or departure demand peaks on runway capacity can be important. For this reason a range of percent arrivals should be considered. Fifty percent arrivals should not be arbitrarily picked as the best planning number.

For runway use configurations that do not have mixed operations on each runway, the specified value of percent arrival can produce a capacity result that does not use each runway to its full capability. For example, a close parallel runway configuration with arrival operations on one runway and departure operations on the other might have an hourly capacity of 30 arrivals and 50 departures for a total capacity of 80 operations. However, if 50 percent arrivals is specified, the total capacity will be 60. Twenty more departures per hour are possible but are not consistent with the 50 percent arrival requirement. Many runway use configurations can accommodate more departures (and in some cases more arrivals) than are required to satisfy a requirement of 50 percent arrivals. For these configurations the user should consider the capacity that gives the maximum number of arrivals with all possible departures. This is discussed in Chapters 2 and 3 as the 9999 option.

j. Touch-and-GO Operation. A touch-and-go operation refers to an aircraft landing and immediately taking off without making a full stop. It is counted as two aircraft operations.

Significant numbers of touch-and-go operations do not occur at airports used predominately by air carrier aircraft. Therefore, the influence of touch-and-go operations in the planning of such airports may not be important. Touch-and-go operations are important, however, at airports with a high percentage of general aviation aircraft operations.

k. Operating Condition. The operating condition defines the physical, procedural and institutional environment under which arrival and departure operations are conducted. This environment is influenced by the portions of the Air Traffic Control Handbook dictated by ceiling, visibility and other factors; navigational aids present; demand pressure; facility procedures; airline policies; and normal pilot-controller actions. Any number of operating conditions could be defined.

Three operating conditions used in this report are defined below. Each chapter contains further assumptions regarding operating conditions appropriate for that model.

VFR. In the airspace adjacent to an airport with a control zone, VFR (Visual Flight Rule) conditions occur when the ceiling is a least 1000 feet and visibility is at least 3 statute miles. In this environment, aircraft operating under visual flight rules provide their own separation from other aircraft in the traffic pattern. Aircraft coming into the control zone on an IFR flight plan (in VFR weather conditions) are assumed to be cleared for a visual approach when they join the traffic pattern or have the airport in sight. Visual approaches may require that the ceiling be at least 500 feet above the minimum vectoring altitude (which is airport specific). Refer to "Air Traffic Control Handbook" 7110.65 for a more complete discussion of "visual approach."

IFR. IFR (Instrument Flight Rule) conditions occur when the ceiling is less than 1,000 feet and/or visibility is less than 3 statute miles. During IFR conditions, the air traffic control system assumes the responsibility for providing separation between all aircraft. It is assumed that operations in IFR conditions are conducted in a radar environment and that arrivals operate on at least one runway equipped with an instrument landing system (ILS). In IFR conditions operations are assumed to be conducted with "visual separations" once the arrival is below the ceiling or in sight of the airport. Refer to "Air Traffic Control Handbook" 7110.65 for a more complete discussion of "visual separation" in IFR.

PVC. In IFR conditions, the occurrence of certain poor ceiling and visibility conditions may substantially reduce runway capacity. In this report these conditions are called Poor Visibility Conditions or PVC. No visual relief is permitted to the air traffic control separation standards in this environment. However, the controller is assumed to be able to tell (by visual contact or electronics) when an arrival has landed on the runway.

l. Model. The word "model" is used to refer to a set of Fortran IV instructions for calculating capacity or delay. The word model is used in conjunction with 21 unique sets of Fortran IV instructions. These are illustrated on Figure 1-2.

m. Submodel. The word "submodel" is used to refer to the first division of a model. Submodel is only used in connection with runway capacity models. There, it always refers to the strategy for using the runway(s) by arrivals and departures.

n. Branch. The word "branch" is used to refer to the division of a submodel into logical statements for calculating capacity for different operating conditions (VFR, IFR or PVC).

o. Batch Capacity Model. The expression "Batch Capacity Model" is used to refer to all runway capacity models plus the taxiway and gate models. It is called "batch" because inputs to the model are normally made on IBM cards via a card reader.

p. Runway Capacity Model. The expression "runway capacity model" is used to refer to all models that compute hourly runway capacity; i.e., single runway model, two parallel runway model, two intersecting runway model, etc.

q. On-line Model. This expression describes the process of using a teletype timesharing terminal with a computer generated question and answer tutorial program.

1.4 Model Overview

The FAA has developed a series of computer models for the analysis of the airside of an airport. These models can be used to determine the capacity and delay on airports, and to study the fine-grain sensitivity of capacity and delay to variations of airport specific conditions.

The models are analytic models; i.e., closed form equations.

Analytic models were developed to determine the hourly capacity of individual airfield components--the runways, the taxiways and the gates. Capacity submodels were developed for over 100 runway use configurations.

The models calculate capacity as the inverse of the average service time for all aircraft being served. For example, if it takes an average of 45 seconds for aircraft to be "served" on a runway, the capacity of the runway equals one aircraft operation per 45 seconds, or 80 operations per hour.

Analytic models have also been developed for determining Annual Service Volume and Annual Delay. The Annual Service Volume Model computes the product of the weighted average hourly capacity, hourly peaking factor and daily peaking factor. The Annual Delay Model computes delay for each representative hour of the year and produces a weighted average annual delay per operation based on input values of weather and capacity distributions.

On-line models were developed to work in conjunction with the Batch Capacity Model, Annual Delay Model and to compute Annual Service Volume. The On-line Runway Capacity Model is a tutorial program with stored data that accesses the Batch Capacity Model to compute capacity. The model logic (i.e., equations) for the On-line Runway Capacity Model and the Batch Capacity Model are identical. The On-line Annual Delay Model is a special adaptation of the Annual Delay Model. The full input capability of the Annual Delay Model is available through the On-line Annual Delay Model. However, the distributions of capacity, demand and weather are in fixed intervals; i.e., monthly, daily, hourly, VFR, IFR and PVC. As an option, stored data can be called for some parameters. The Annual Service Volume Model is only available in a tutorial on-line model. No built in data is available.

1.5 Model Availability

The models described in this report are available for airport planning. A magnetic tape containing the Runway Capacity Batch Model, On-line Airfield Capacity Model, Annual Delay Model, On-line Annual Delay Model, and On-line Annual Service Volume Model may be purchased from:

National Technical Information Service
Attn: Order Desk
5285 Port Royal Road
Springfield, VA 22161

1.6 Configuration Control

Configuration control is being exercised by the FAA over the models contained in this report. This is for the purpose of documenting changes and extending model capabilities. The following are valid programs as of

Batch Capacity Model

Batch Annual Delay Model
On-line Runway Capacity Model
On-line Annual Service Volume Model
On-line Annual Delay Model

1.7 Computer Requirements

All the computer programs referenced in this report are written in a basic form of FORTRAN IV and should be readily useable on any FORTRAN compatible computer. The following table defines the approximate core requirements for each program.

Model	Core Requirement
Batch Capacity Model Version 5	210k bytes
Annual Delay Version 1	30k (octal) on CDC CYBER 74

Aircraft Classification	Types of Aircraft
Class A	Small single-engine aircraft weighing 12,500 lbs. or less (e.g., PA18, PA23, C180, C207)
Class B	Small twin-engine aircraft weighing 12,500 lbs. or less and Lear jets (e.g., BE31, BE55, BE80, BE99, C310, C402, LR25)
Class C	Large aircraft weighing more than 12,500 lbs. and up to 300,000 lbs. (e.g., CV34, CV58, CV88, CV99, DC4, DC6, DC7, L188, L49, DC8-10, 20 series, DC9, B737, B727, B720, B707-120, BA11, S210)
Class D	Heavy aircraft weighing more than 300,000 lbs. (e.g., L1011; DC8-30, 40 50, 60 series; DC10; B707-300 series; B747; VC10; A300; Concorde; IL62)

---

a. For aircraft type designation, see FAA Order No. 7340.1E with changes.

b. Weights refer to maximum certificated gross take-off weight.

c. Heavy Jet aircraft are capable of 300,000 pounds or more whether or not they are operating at this weight during a particular phase of flight. (Reference: FAA Handbook 7110.8D with changes.)

NOTE: These aircraft classifications generally follow the TERPS categorization. It does not follow the previous categorization used in AC150/5060-1A "Airport Capacity Criteria Used in Preparing the National Airport Plan"; i.e., the "red book."

FIGURE 1-1

AIRCRAFT CLASSIFICATION

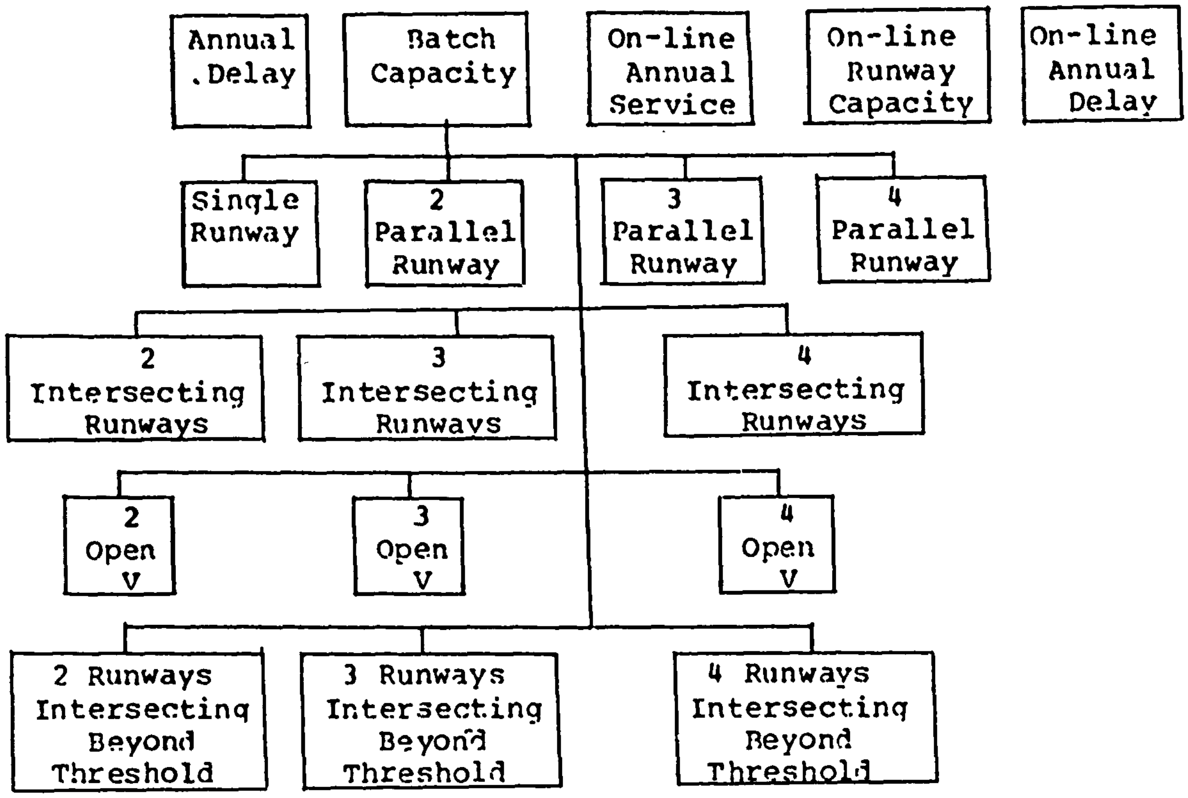


FIGURE 1-2

MODELS

CHAPTER 2 -- RUNWAY CAPACITY, BATCH MODEL

2.1 Introduction

2.1.1 Overview

The FAA Airport Capacity Model is a computer program which analytically calculates the maximum throughput of a runway system. In the program, "capacity" is defined as the maximum sustainable runway throughput, on a long-term basis, of arrivals and departures given a continuous sustained demand. Although actual throughput may be different, due to short-run variations in aircraft mix, control procedures, etc., this theoretical capacity is valid for comparisons between airports or between developmental alternatives.

Capacity is computed by determining the minimum time between successive arrivals and inverting this time to find the maximum number of arrivals per hour. The maximum number of departures which can be inserted between the arrivals is then calculated, to give the "arrival-priority" capacity. If a specific ratio of arrivals to departures is specified, the departure-priority capacity is calculated. The desired capacity may be obtained by dropping excess arrivals or departures, or by interpolating between the arrival-priority and departure-priority points.

Details of the capacity calculations are described in the next Section. The technique for achieving the desired arrival-departure ratio is described in Section 2.3, along with other information about the general program workings.

The input items required for the calculations will be described in Section 2.4 along with the required data formats. Section 2.5 will discuss output. Some details of the program software and operating procedures will be given in Section 2.6. Section 2.7 contains reference tables describing the breakdown of complex runway configurations into simpler components. Lastly, several examples will be presented and discussed in Section 2.8.

2.1.2 Definition of Terms

In the following discussion, the term "runway configuration" will mean a unique runway layout, with a specified number and arrangement of runways, and with the arrivals and departures assigned to particular runways. A "model" is the subsection of the program logic, representing a general runway geometry which is unique for each configuration. Thirteen major geometries, or models, are represented in the program:

Model No.	Geometry
1	Single Runway
2	Two Parallel Runways
6	Two Intersecting Runways
3	Three Parallel Runways
4	Four Parallel Runways
5	Two Open V Runways
7	Three Intersecting Runways
10	Three Open V Runways
11	Four Open V Runways
12	Two Runways Intersecting Beyond Threshold
13	Three Runways Intersecting Beyond Threshold
14	Four Runways Intersecting Beyond Threshold
15	Four Intersecting Runways

Typical layouts of these geometries are depicted in Figure 2-1.

For each model, the operating strategy must also be specified. The "operating strategy" defines whether a runway is used for arrivals, departures, or mixed operations. It can also provide some information on the spacing between parallel runways and whether operations on non-parallel runways are converging or diverging. For example, model 2 (two parallel runways), strategy 20 represents a close-spaced pair (700-2499 ft apart), with arrivals on runway 1 and departures on runway 2. This configuration can also be referred to in a shorthand form as 2-20(C:A,D).

The strategy codes are unique for each model. A complete listing and explanation of each model and strategy combination appears later in this chapter, in Section 2.7.

2.2 Capacity Calculation Logic

The development of the Airfield Capacity Model logic equations is contained in References A and C. This section presents a summary of the Airfield Capacity Model logic.

2.2.1 Arrival Operations On a Single Runway, Model 1-1(A)

The capacity of an arrival-only runway is given by:

$$\text{CAPACITY} = \frac{3600}{\text{average time separation between arrivals}} = \frac{3600}{\text{TAA}}$$

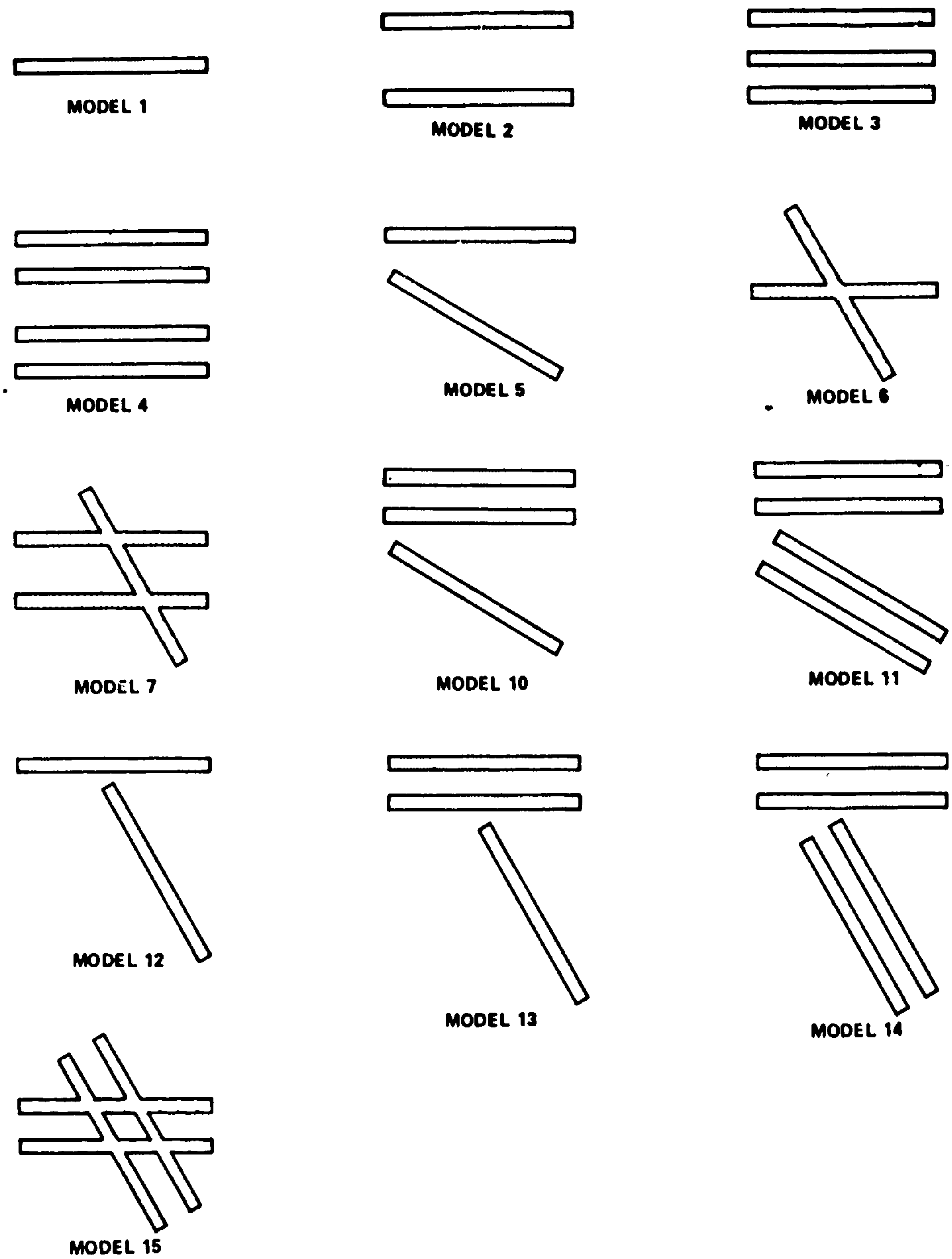


FIGURE 2-1
RUNWAY USE CONFIGURATION GEOMETRIES

Model 1-1(A) determines the required time separation for each aircraft class pair ($\overline{TAA}(i,j)$) by comparing the arrival runway occupancy time of the lead aircraft i and the time separation over threshold for the aircraft pair ij. The larger of these two values is assumed to be the required time separation over threshold for this pair of arrival aircraft classes. The frequency with which each aircraft class pair would occur is assumed to be the product of the mixes of the aircraft classes involved: e.g., the frequency of occurrence of aircraft class pair ij = %i X %j / 1000. Therefore, the average time separation between arrival pairs is computed as the sum over all class pairs of the product of $\overline{TAA}(i,j)$ for each aircraft class pair and the frequency with which the aircraft class pair is expected to occur:

$$TAA = \sum_{i,j} \overline{TAA}(i,j) * \%i * \%j \;/\; 1000$$

In determining arrival runway occupancy time and the time between arrivals the Airfield Capacity Model considers the variability of aircraft, pilots and controllers as expressed by the standard deviations of arrival runway occupancy time and arrival-arrival separation. In addition, in determining the time between arrivals over the threshold, the Airfield Capacity Model considers the approach velocities of the aircraft pair and the length of the common final approach path. If the velocity of the trailing aircraft is operating at a lower velocity than the lead aircraft, the specified minimum arrival-arrival separation is assured at the merge point of the two approach paths.

?.2.2 Departure Operations On a Single Runway, Model 1-2(D)

The capacity of a departure-only runway is given by:

$$\text{CAPACITY} = \frac{3600}{\text{average time separation between departures}} = \frac{3600}{\text{TDD}}$$

Model 1-2 determines the required time separation for each aircraft class pair ($\overline{TDD}(k,l)$) by comparing the departure runway occupancy time of the lead aircraft k and the time separation between departures (from threshold) for the aircraft pair kl. The larger of these two values is assumed to be the required time separation at threshold for this pair of departure aircraft classes. The average time separation between departures is computed as the sum over all

class pairs of the product of $\overline{TDD}(k,l)$) for each aircraft class pair and the frequency with which the aircraft class pair is expected to occur.

$$TDD = \sum_{k,l} \overline{TDD}(k,l) * \%k * \%l \;/\; 1000$$

2.2.3 Mixed Operations On a Single Runway, Model 1-3(B)

The capacity (without regard to arrival percentage) of a single runway used by arrivals and departures is given by:

CAPACITY = (Arrival only runway capacity) + (Number of departures that can be inserted between arrivals)

To insert departures between arrival pairs, Model 1-3(B) imposes the following requirements:

- departures cannot roll if an arrival is on the runway
- departures cannot roll if:
  - (1) an arrival is within some specified distance of the runway threshold, or
  - (2) the departure cannot clear the runway before the arrival comes over the threshold
- departure-departure separations must be met to insert multiple departures between an arrival pair.

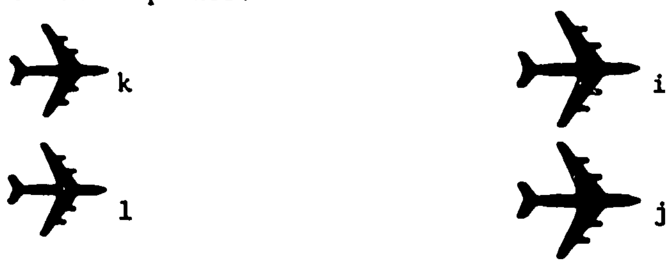
Employing these conditions, Model 1-3 computes the probability of inserting 1, 2 or 3 departures between each arrival pair. The interleaved departure capacity is then determined from these probabilities and the aircraft mix.

2.2.4 Simultaneous Arrival Operations on Close Spaced Parallel Runways in VMC, Model 2-19(C:A,A) and Model 2-24(C:B,B)

In VFR operating conditions, simultaneous arrival operations can be made to close spaced parallel runways (i.e., runways with centerline separations from 700 to 2499 feet) if neither of the aircraft is a heavy jet. When a heavy jet is present on the final approach path, the runways become dependent and the trailing aircraft on both runways are required to observe the single runway wake turbulence

separations (e.g., 4 nmi for heavy-heavy and large-small, 5 nmi for heavy-large and 6 nmi for heavy-small aircraft pairs under current procedures).

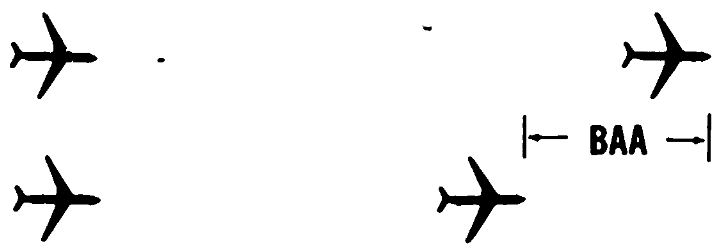
To compute this capacity, the program considers the following quadruplet of airplanes:



If neither of the lead aircraft (i or j) is a heavy, the two arrival streams are independent, and the airfield capacity is the sum of the single runway capacities. If one or both lead aircraft is heavy, the program calculates all four possible separations (i-k, i-l, j-k, and j-l), and takes the largest separation to be governing for this quadruplet. An average weighted separation is then obtained for all appropriate quadruplets of aircraft classes. The capacity thus obtained is weighted by the probability that one or both lead aircraft is a heavy, and combined with the weighted capacity of the non-heavy case, to obtain an overall arrival capacity.

If mixed operations occur on either runway, the departure capacities are also calculated for the vortex and non-vortex cases and then combined to given an overall departure capacity.

NOTE: For this runway use configuration, it is possible to specify a buffer time separation (BAA) between the lead aircraft pair as illustrated below:



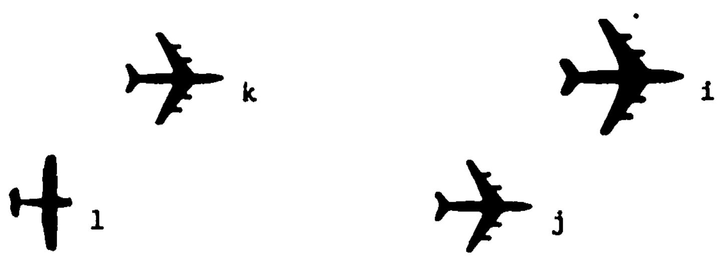
This buffer between simultaneous arrivals is normally used to keep faster wake turbulence producing aircraft from getting ahead of slower aircraft on a parallel approach by the time the aircraft pair reaches the runway thresholds.

2.2.5 Arrival Operations on Intermediate Spaced Parallel Runways in IMC, Model 2-7(M:A,A)

As used in this report, intermediate parallel runways are those with centerline separation between 2500 and 4299 feet. In IFR operating conditions, simultaneous arrival approaches cannot be made on these runways. However, since the runway centerline separation is equal to or greater than 2500 feet, no increased arrival separation is required for cross track wake turbulence; a 3.0 nmi separation can be applied intrail between aircraft on different runways. Full separations, including wake vortex buffers, apply between consecutive arrivals to the same runway.

Recent changes to ATC procedures allow such alternating arrivals to be run using a 2.0 nmi diagonal separation if the runways are separated by 3000 feet or more. The Capacity Model can calculate these capacities as well.

Whether intrail or diagonal separations are used, the program considers a quadruplet of four aircraft, ijkl:



The interval between arrivals i and j is calculated first, based on the intrail or diagonal separation. The arrival time of k is then calculated, as constrained by:

- the diagonal or intrail separation between j and k,
- the intrail separation between i and k, and
- the runway occupancy time of arrival i.

The process is repeated for arrival l. The difference between arrival times for j and l is averaged for all combinations of i, j, k, and l, then inverted to obtain the arrival capacity of each runway.

2.2.6 Dual-lane Runway -- Close Parallels, Arrivals On One and Departures On the Other -- Model 2-20(C:A,D)

In IMC, operations on a close parallel pair of runways are dependent. Departures on one runway cannot be released if an arrival to the other runway is within a certain distance of the threshold (the departure/arrival separation), but can be released as soon as the arrival touches down.

The logic for computing the departure capacity of this configuration is similar to that used for the single runway, Model 1-3(B). After the interarrival times are obtained, the probability of 1, 2, or 3 departures in each interarrival gap is calculated. The runway occupancy time of the arrival is not a constraint, but an additional constraint applies: departure-departure separations are enforced, not just between departures in the same gap, but also between departures in adjacent gaps. This is rarely necessary for mixed operations on a single runway because the need to wait for the arrival to exit the runway is usually limiting.

2.2.7 Two Intersecting Runways With Arrivals On One and Departures On the Other -- Model 6-2(A,D)

The logic for intersecting runways and that for dual-lane runways are similar. The probability of 1, 2, or 3 departures per inter-arrival gap is subject to:

- the time for an arrival to clear the intersection or exit the runway,
- the required departure/arrival separation existing when the departure crosses the intersection,
- required departure/departure separation, enforced between departures within a gap and also between departures in adjacent gaps.

If departure and arrival flight paths are projected to cross, additional wake turbulence separation (currently 2 minutes) through the intersection is required. To analyze this special case, the Delay Simulation Model discussed in Chapter 4 is recommended. These conditions could possibly occur when the distance from the arrival threshold to intersection is less than 2000 feet and the distance from departure threshold to intersection is more than 5000 feet.

2.2.8 Combinations of Models

The models for most of the remaining runway use configurations are combinations of the prime equations discussed above. For example, Model 2-16(M:3,A) in VFR is the sum of the capacity for the Single Runway Model with mixed operations (1-3(B) and the Single Runway Model with arrivals only (1-1(A). Model 13-2(DV:B,B,D) -- three runways intersecting beyond, diverging -- in VMC is made up of the Two Parallel Runway Model with mixed operations for close spaced runways (2-24(C:B,B)) and the Single Runway Model for departures only (1-2(D)).

2.3 Additional Program Logic

The above section described the general logic used to compute runway capacity. The following paragraphs address some of the specific details and assumptions of the calculations.

2.3.1 Arrival Percentage Logic

The equations for computing capacity contained in the previous subparagraphs did not consider the desired percentage of arrivals. These equations were based on arrivals having preemptive priority; the capacity so calculated is therefore referred to as the "arrival-priority" capacity. To arrive at the desired arrival percentage, the following methodology is used:

- o If the arrival-priority capacity provides more departures than needed for the specified arrival percentage, the excess departures are eliminated.

- o If additional departure capacity is required, the "departure-priority" capacity is then calculated. This is obtained by revising the runway configurations, eliminating all arrival streams that may interfere with the departure streams, in order to maximize the number of departures.

- o If the departure-priority capacity provides an excess of departures, the program balances the arrival-priority and departure-priority capacities, operating each for a portion of the hour, in order to obtain the specified arrival percentage.

- o If the departure-priority capacity provides too many arrivals, the excess are eliminated to obtain the desired arrival percentage.

For example, the capacity (without regard to percent arrivals) for a runway configuration is 35 arrivals and 60 departures. If the user had specified 50% arrivals, the program would eliminate the departures in excess of the arrival capacity and list the capacity as 35 arrivals and 35 departures, a total of 70 operations/hour. Twenty-five more departures per hour are possible but are not required for the specified arrival percentage.

For another example, the hourly capacity (without regard to percent arrivals) of a single runway with mixed operations is 35 arrivals and 15 departures.

If the user specified 50% arrivals, the departure-priority capacity would be computed. Eliminating the interfering arrival stream leaves a departures-only runway, with a capacity of (for example) 50 departures per hour. Balancing these two capacities results in 25 arrivals and 25 departures per hour.

The program assumes that individual runways will be used in a way which maximizes total capacity. Any factors which prevent such usage must be recognized, and the program results adjusted accordingly. For example, if a runway configuration consisted of four parallel runways, where two runways were used for mixed operations, one runway was used for arrivals only, and one runway was used for departures only, the capacities might be:

		Capacity	
Runway	Operation	Arrival	Departure
1	Mixed	35	25
2	Mixed	35	20
3	Arrival	35	0
4	Departure	0	60
		105	105

The capacity for all four runways at 50% arrivals is 210. However, if the constraint was imposed to have half the demand on runways 1 and 2 and half on runways 3 and 4, the capacity would be substantially less; i.e., 116 + 70 = 186.

In such cases, it is advisable to calculate the capacity of each runway or dependent runway pair separately and apply the percent arrival technique manually. This procedure is described in Appendix A.

2.3.2 Gap Stretching

In reality, an arrival/departure runway would not be run under arrival-priority for part of the hour and departures-only for the remainder, as the above section implies. Such an apportionment between operating modes is only intended as an approximation of the real world, in which controllers selectively stretch the gaps between arrivals in order to fit in more departures.

This gap stretching can now be modeled more directly by the capacity program. The logic operates as follows: each interarrival gap is stretched by a user-specified increment (e.g. 10 seconds). Departure capacity is then recomputed. If the gap stretch for a particular aircraft pair does not provide a net capacity benefit, the gap is returned to its previous size. Arrival and departure capacities are then calculated and printed for the resulting combination of stretched and unstretched gaps.

For the second gap-stretching, each interarrival gap is stretched by two increments (in this case, 20 seconds), compared to its unstretched size. After testing for net capacity benefit, some gaps might retain the 20 second stretch, others only 10 seconds, and some might not be stretched at all.

The user may specify both the increment used for gap stretching, and the maximum number of additional capacity points to be calculated. It is suggested that increments of 10 to 30 seconds be used. Large gap stretches will not produce the capacity benefit which might be expected, since the program is limited to consider no more than three departures per arrival gap.

2.3.3 First Enqueued Departure Mix

In the process of inserting departures into the arrival gaps, the program compensates for the fact that certain aircraft types are more likely to be released than others. One way this is done is through the first enqueued departure (f.e.d.) mix. If an aircraft is not released in the current interarrival gap, it will be first in the queue to be released in the next gap. An iterative technique which converges quickly is used to determine the f.e.d. mix, PFED(i,k), the probability that a departure of type k will be first in line after an arrival of type i. The maximum number of iterations and the convergence criterion can be user-specified.

This procedure removes most of the potential imbalance between types in the departure mix. Any remaining imbalance is accounted for by basing departure capacity on the most limiting aircraft type. For

example, if 24 departures of type A aircraft are possible, and 26 type B departures in an hour, but each type represents 50% of the overall fleet, the departure capacity will be 48 (24/0.5). Otherwise, type A aircraft would be under-represented in the departure mix.

2.3.4 Operating Conditions

The Airfield Capacity Model recognizes three separate weather conditions:

- o VMC -- Visual Meteorological Conditions
- o IMC -- Instrument Meteorological Conditions
- o MMC -- Marginal Meteorological Conditions

In VMC, Visual Flight Rules (VFR) apply; in IMC, Instrument Flight Rules (IFR) are enforced. MMC is basically an IFR environment, but visibility is good enough that the 2.0 nmi departure/arrival separation in IMC is superceded by the application of visual separations. This only affects certain runway configurations, those which include (or are modeled as if they included) a single, mixed-operations runway (1-3(B)) or a close-spaced parallel pair with arrivals on one and departures on the other (2-20(C:A,D) and 2-22 through 2-24). Additionally, the table of runway configurations that will be presented in Section 2.7 will indicate whether separate logic exists for the MMC case.

MMC differs from IMC in another manner as well. It is assumed that two intersecting runways can be used with departures on both in MMC, but in IMC visibility is too poor for the controller to see the intersection, and so departures are conducted on only one runway.

These differences between the weather conditions are summarized in Table 2-1.

2.3.5 Aircraft Mix

In general, the definition of aircraft classes used in the Airfield Capacity Model is at the user's discretion. However, the logic of certain runway models will treat D type aircraft as wake turbulence producing aircraft and apply special wake turbulence air traffic control separation criteria.

This is done in VMC if the configuration includes (or is modeled as if it included) a close-spaced parallel pair with arrivals on both

TABLE 2-1

EXPLANATION OF WEATHER CONDITIONS

WEATHER		VISIBILITY* (STAT. MI.)	CEILING* (FEET)	OPERATIONAL IMPACT
VMC	VISUAL METEOROLOGICAL CONDITIONS	5.0	5000	VISUAL APPROACHES -- PARALLEL RUNWAYS >700' APART ARE INDEPENDENT
MMC	MARGINAL METEOROLOGICAL CONDITIONS	2.5	900	IFR SEPARATIONS APPLY BETWEEN ARRIVALS -- PARALLEL RUNWAYS <4300' APART HAVE DEPENDENT ARRIVAL OPERATIONS -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS >700' APART ARE INDEPENDENT BECAUSE VISUAL SEPARATIONS ARE APPLIED
IMC	INSTRUMENT METEOROLOGICAL CONDITIONS	0.0	0	ALL IFR PROCEDURES ARE IN EFFECT -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS <2500' APART ARE DEPENDENT

*THESE ARE VALUES WHICH ARE INPUT TO THE PROGRAM, NOT BREAKPOINTS BETWEEN WEATHER CONDITIONS

or departures on both (2-19(C:A,A) and 2-21 through 24). The logic for such cases has been discussed in Section 2.2.4.

This same assumption about D-type aircraft is made for intersecting runways with departures on both in VMC and MMC, because of the need to provide proper wake vortex protection if both aircraft are airborne at the intersection. (See Section 2.2.7.)

The mix of aircraft types is specified for each runway. Unless specific restrictions apply, the mix on each runway is generally the same. If the mixes differ, care must be taken that the capacity results do not distort the overall airport mix. For example, the capacity of a short, general-aviation runway may be 37 operations per hour, but if general aviation only constitutes 10% of the total airport mix, it is doubtful that the full capacity of the runway will be utilized. On the other hand, the addition of such a runway may increase the general aviation traffic at the airport to more than 10% of the total. Such questions must be resolved by the model user, outside the model itself.

In some cases the individual runway mixes are not used, but rather the mixes on two runways are averaged together. This occurs in MMC and IMC for close parallel runways with arrivals on both (2-19(C:A,A)) or with departures on both (2-21(C:D,D)). The assumption is that such operations, being dependent under Instrument Rules, will be conducted on a single runway.

2.3.6 Minimum Arrival Separation

The input parameter DLTAIJ is defined as the "minimum" separation between a pair of arrivals over the length of their common approach path. The Airfield Capacity Model converts the minimum arrival separation into an average arrival-arrival separation over threshold by the following formula:

Average Separation Over Threshold = (Minimum Separation)
+ (Control System Buffer) + (Velocity Differential)

The average arrival-arrival separation over threshold (AASR(i,j)) is used by the Airfield Capacity Model in the computation of capacity. The minimum arrival-arrival separation DLTAIJ is one factor in determining the average arrival-arrival separation over threshold.

There are several ways to look at the meaning of DLTAIJ and AASR.

DLTAIJ can be regarded as the air traffic control separations specified in 7110.65B "Air Traffic Control Handbook." These are IFR separations; under VFR, visual separations (which are not as great) would apply. Suggested values for minimum VMC separations, as well as IFR and VFR separations for future ATC environment, may be found in [illegible]-EM-78-8A, "Parameters of Future ATC Systems Relating to Airport Cap[illegible]ty/Delay."

Alternatively, the actual [illegible]rved separations over the threshold can be used to determine AASR and the[illegible]re DLTAIJ. The use of observed data should be approached cautiously in order to avoid:

- o small sample sizes
- o non-representative operating conditions
- o non-saturated demand

any of which would distort the results. (Appendix A of FAA-EM-78-8A provides some additional guidelines for the use of observed data.) Methods for converting AASR(i,j) values into DLTAIJ(i,j) values or DLTAIJ(i,j) values into AASR(i,j) values are described in Appendix B.

2.4 Input Format

2.4.1 General Information

This section will describe, line-by-line, the requirements for constructing an input file for the Airfield Capacity Model. The following general information applies:

- o Each input item consists of two lines, the header card and the data card, e.g.,

```
RUNWAY 2 1 0              (header)
0.250.250.250.25          (data).
```

- o There is no fixed sequence for groups of header/data cards.
- o Each header card contains the following data:

cc 1-6	NAME	(A6)	arbitrary title for identifying each data item, e.g., RUNWAY
cc 8	IRUM	(I2)	runway number, when needed

cc 9-10	INDEX	(I2)	input data type number
cc 12	NCARD	(I2)	execution command -- 1 if the last input item for a run, otherwise 0 or blank
cc 13-80	ALPHA	(A68)	available for comments by user -- must start prior to cc 20.

- o If there are four items on a data line, one for each aircraft class, they should be input in order, from the smallest class to the largest:

  A B C D

- o If there are sixteen items on a data line (4 classes for the lead aircraft and 4 for the trailing), they should be entered as follows:

  AA AB AC AD BA BB BC BD CA CB CC CD DA DB DC DD

  where AB indicates a class A aircraft followed by a class B.

- o To execute a run, the value of NCARD is 1. Additional cases can be run with a single input file by placing additional lines, for the items to be added or changed, after the last line for the first case. The last input item for each case must have NCARD = 1 on the header line.

- o The number of cases which can be contained in a single data file is almost unlimited; however, long data files increase the risk of losing track of the current values of the variables.

A sample coding form illustrating the format for the input items is shown in Figure 2-2. Examples of typical input files will be shown in Section 2.8.

2.4.2 Specific Data Items

Although each header card has the same format, the format of each data card depends on the type of data it contains. The following section will describe in detail the variables and format of each data card. The data lines will be referred to by the NAME assigned by the interactive section of the program and by the INDEX number. The user may change the NAME, but cannot change the INDEX.

1–4	5–8	9–12	13–16	17–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	49–52	53–56	57–60	61–64	65
NEWR	UN	0 0		text												
imodel	istrgy	ialt														
RUNW	AY 1	1		text												
a	b	c	d													
RUNW	AY 2	1		text												
a	b	c	d													
ARBA	R2 1	2														
a	b	c	d													
ARBA	R2 2	2														
a	b	c	d													
DLTA	IJ	4														
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd	
APPS	PD	5														
a	b	c	d													
DRBA	R	6														
a	b	c	d													
TD		7														
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd	

FIGURE 2-2
SAMPLE INPUT CODING FORM

1 2 3 4	5 6 7 8	9 10 11 12	13 14 15 16	17 18 19 20	21 22 23 24	25 26 27 28	29 30 31 32	33 34 35 36	37 38 39 40	41 42 43 44	45 46 47 48	49 50 51 52	53 54 55 56	57 58 59 60	61 62 63 64	65
GAMA		8														
a	b	c	d													
TGRB	AR	9														
a	b	c	d													
OPEN	V	10														
theta	openvx	adsrx	dicbrx													
TWOI	N	11														
iax	sigai	sigdi	txi(a,1)	(b,1)	(c,1)	(d,1)	(a,2)	(b,2)	(c,2)	(d,2)						
ADSR	1	12														
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd	
DICB	R	13														
aa	ab	a	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd	
SIGM	AS	19														
sigmar	sigmaa	sigtgr	sigmac	sigmdr												
OTHE	RS	20														
pv	pvi	dltada	vis	ceiling	gslope	potg	ipa#1	ipa#2	etc.	[up to	11 values]					
BDD		22														
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd	

FIGURE 2-2
SAMPLE INPUT CODING FORM
(Cont.)

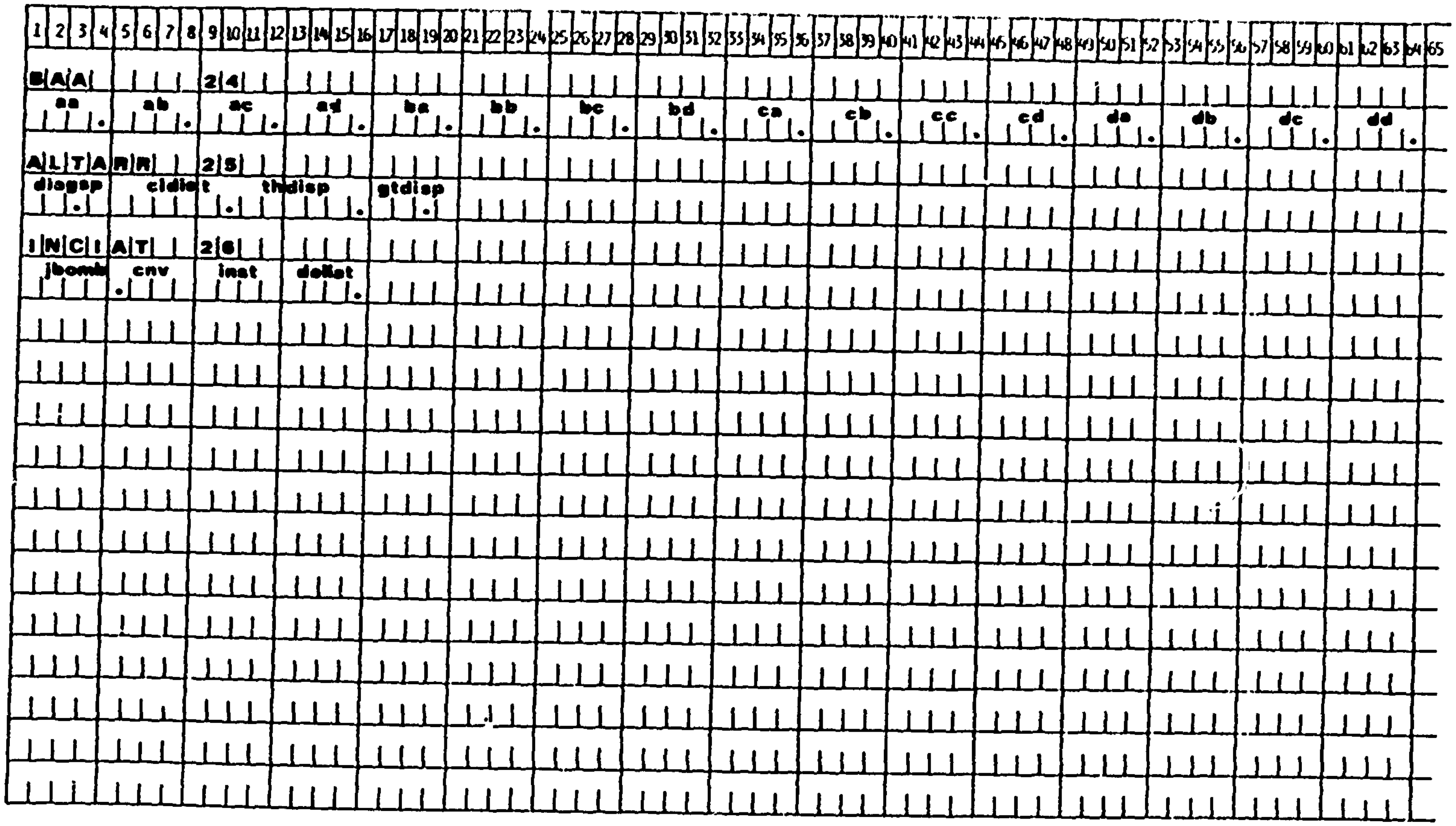


FIGURE 2-2
SAMPLE INPUT CODING FORM
(Cont.)

The format for each variable is shown in FORTRAN notation. I4 indicates four columns of integer data (a decimal point should not be used). F4.1 indicates four columns of floating-point data with one place to the right of the decimal point; however, the program will correctly read the input regardless of the location of the decimal.

<u>NEWRUN---0</u>

IMODEL - (I4) cc 1-4

- the model number (1 to 15) of the runway configuration to be studied, e.g., 1 (single runway), 6 (two intersecting).

ISTRGY - (I4) cc 5-8

- the operational strategy. Together, IMODEL and ISTRGY determine the configuration, e.g., 1-3 means mixed operations on a single runway.
- details of all the available model and strategy combinations are presentsd in Section 2.7.1.

IALT - (I4) cc 9-12

- indicates whether alternating arrivals are to be conducted to parallel runways.
- 0 indicates no stagger is to be run, 1 indicates alternating arrivals are to be conducted, if the runways are 3000 feet apart or more.

<u>RUNWAY---1</u>

PHR (I,IRUM) - (4F4.2)

- proportion of aircraft type I on runway IRUM (4 values, smallest aircraft type first).
- must be input for each runway in the configuration--specify IRUM on the header line.

<u>ARBAR2----2</u>

ARBAR (IRUM,I) - (4F4.0)

- average arrival runway occupancy time of aircraft type I on runway IRUM (4 values).

- must be input for each arrival runway in the configuration.
- if the average times are not known, estimates can be obtained by using the technique of Section 2.7.2.

EXITPT---3 - No longer used in the revised version

DLTAIJ---4

DLTAIJ (I,J) - (16F4.1) - minimum arrival separations, in nmi, for aircraft type J following type I.

APPSPD---5

V(I) - (4I4) cc 1-16 - final approach speed, in knots, for class I (4 values).

DRBAR----6

DRBAR(I) - (4I4)
- average departure runway occupancy time, in seconds, for class I (4 values).
- Time from start of roll to liftoff.

TD-------7

DDSR(I,J) - (16I4) - minimum departure separations, in seconds, for class J behind class I (16 values)

GAMA-----8

GAMA(I) - (4I4)
- length of final approach path, in nmi, for class I (4 values).
- same values are used for all arrival runways.
- for alternating arrivals, enter values for runway 1 (see GTDISP).

TGRBAR---9

TGRBAR(I) - (4F4.0)		-	touch-and-go runway occupancy time, in seconds, for class I (4 values).
		-	not needed if POTG (see OTHERS--20) is zero.

OPENV---10 - needed for models 5, 10, 11, 12, 13, 14

THETA - (I4)	cc 1-4	-	angle, in degrees, between two open V runways.
OPENVX - (I4)	cc 5-8	-	distance, in feet, between the thresholds of the two open-V runways.
ADSRX - (F4.1)	cc 9-12	-	see ADSR----12. If ADSRX is non-zero, ADSR(I,J) is set equal to ADSRX for all I and J. Otherwise ADSR(I,J) is set to 10 seconds.
DICBRX - (F4.1)	cc 13-16	-	see DICBR---13. Similarly to ADSRX, DICBR(I,J) is set equal to DICBRX or 2.0 nmi.

TWOIN---11 - needed for models 6-1, 6-3, 7-1, 7-2 (also 6-2 if SIGAI and SIGDI are non-zero).

IAX - (I4)	cc 1-4	-	airborne intersection indicator.
		-	0 means aircraft are not airborne at intersection. 1 means aircraft are airborne at intersection and special vortex separations apply.
SIGAI - (F4.1)	cc 5-8	-	the standard deviation of the time for arrivals to clear the intersection, in seconds.
SIGDI - (F4.1)	cc 9-12	-	the standard deviation of the time for departures to clear the intersection, in seconds.

TXI(I,K) - (8F4.0) cc 13-44

- the average time, in seconds, for a departure of class I, on runway K, to clear the intersection.
- 4 values for runway 1, followed by 4 values for runway 2.
- does not apply to model 6-2 (may be left blank).

<u>ADSR----12</u> - needed for models 5-4, 5-5, 6-2, 6-3, 7-1, 7-2, 11-3, 11-4, 12-3, 12-4, 14-3, 14-4, 15-1, 15-2.

ADSR(I,J,IRUM) - (16F4.0)

- the separation, in seconds, between arrival I on runway IRUM and departure J on the crossing runway (16 values).
- generally, this is the time after I crosses the threshold at which J can be released.

<u>DICBR---13</u> - also needed for models 5-4, 5-5, 6-2, 6-3, 7-1, 7-2, 11-3, 11-4, 12-3, 12-4, 14-3, 14-4, 15-1, 15-2.

DICBR(I,J) - (16F4.1)

- the separation, in nmi, between departure I and arrival J on the crossing runway (16 values).
- generally, the minimum distance of J from the runway threshold at which I can be released.

<u>14 to 18</u> - no longer used. These items were originally associated with the gate and taxiway capacity models, which have been dropped.

<u>SIGMAS--19</u>

SIGMAR (F4.0) cc 1-4 - standard deviation, in seconds, of arrival runway occupancy time (R.O.T.).

SIGMAA (F4.0) cc 5-8 - standard deviation, in seconds of interarrival time.

SIGTGR (F4.0) cc 9-12 - standard deviation, in seconds of touch and go R.O.T.s.

SIGMAC (F4.0)	cc 13-16	- standard deviation in seconds of cleared-to-roll time.
SIGMDF (F4.0)	cc 17-20	- standard deviation, in seconds of departure R.O.T.

OTHERS--20

PV - (F4.2)	cc 1-4	- probability of violation for arrival R.O.T., etc. Usually 0.05.
PVI - (F4.2)	cc 5-8	- probability of violation for interarrival time only. Usually 0.05 for the present, 0.01 for future cases.
DLTADA - (F4.1)	cc 9-12	- departure/arrival separation, in nmi. The minimum distance of an arrival from the runway threshold in order to release a departure on the same or a close-spaced parallel runway.
VIS - (F4.1)	cc 13-16	- visibility, in statute miles.
CEILNG - (I4)	cc 17-20	- ceiling, in feet.
GSLOPE - (F4.1)	cc 21-24	- glide slope angle, in degrees.
POTG - (F4.2)	cc 25-28	- proportion of touch and go operations. - since a T&G is counted as both an arrival and a departure, POTG must be no greater than twice the arrival percentage or twice the departure percentage. - if POTG is greater than zero, specify only one value for IPA, the arrival percentage.
IPA - (11I4)	cc 29-72	- up to 11 different arrival percentages. - the first arrival percentage may also take on three special values:

- o 9999 - only arrival priority capacity is calculated.
- o 8888 - arrival priority and departure priority capacities are calculated.
- o 7777 - capacity will be calculated for arrival priority, for the maximum number of gap-stretching intermediate points (as specified in INCIAT--26), and for departure priority.

- if these special values are used other than in the first position, they will be ignored.

21 - not used

BDD-----22

BDD(I,J) - (16F4.0) - buffer time, in seconds, between simultaneous departures on close-spaced parallel runways (16 values).

23 - the logic supported by this input has been superceded by the gap-stretching logic (see INCIAT--26).

BAA-----24

BAA(I,J) - (16F4.0) - buffer time, in seconds, between simultaneous arrivals to close-spaced parallel runways (16 values).

ALTARR---25

DIAGSP - (F4.1) cc 1-4 - diagonal separation, in nmi, to be applied between consecutive, alternating arrivals to parallel runways.

- if DIAGSP is any negative value DLTAIJ(I,J) is used for the diagonal separation between I and J on different runways.

CLDIST - (F6.0) cc 5-10 - separation between runway centerlines, in feet.

THDISP - (F6.0) cc 11-16 - displacement of runway thresholds. This is measured from the threshold of runway 1, in the direction of flight. THDISP is, therefore, negative if the r/w2 threshold is reached before the r/wl threshold.

GTDISP - (F4.1) cc 17-20 - the relative displacement, in nmi, of the gates for the two runways, the start of the final approach paths. Again, this is measured forward (positive) or back (negative) from the r/wl gate.

To run alternating arrivals, both the ALTARR data and IALT (on line 0, NEWRUN) should be provided for each case. If both are not provided, the following defaults occur:

- o If IALT > 0 but ALTARR data is not entered, the program assumes

  DIAGSP = 2.0
  CLDIST = 3000.
  THDISP = 0.
  GTDISP = 0.

- o If ALTARR data is entered but IALT is not, IALT = 1 is assumed.

- o If neither IALT nor ALTARR are entered, but the runway capacity would benefit from alternating arrivals (e.g., model 2-7(M:A,A)), the program operates alternating arrivals using a 3.0 nmi (actually, DLTAIJ (1,1)) intrail separation.

To force such an intrail (not diagonal) separation, set IALT = 2 and CLDIST = 0.

INCIAT--26

JBOMB - (I4)	cc 1-4	- the maximum number of iterations on the f.e.d. mix.
CNV - (F4.3)	cc 5-8	- the convergence criterion for f.e.d. mix iterations. If the absolute difference between the old and the new PFED(I,K), for each I and K, is less than CNV, iteration will stop.
INST - (I4)	cc 9-12	- the maximum number of points for which arrival capacity is calculated (the arrival-priority point plus INST-1 intermediate points).
DELIAT - (F4.0)	cc 13-16	- the increment, in seconds, by which the arrival gaps are stretched to obtain the intermediate points.

If this line is not input, these values default to

- o JBOMB = 1
- o CNV = 0.05
- o INST = 2
- o DELIAT = 20 seconds.

2.5 Output

The principal output of the Airfield Capacity Model is the total capacity per hour for a specified arrival percentage. This capacity is without regard to delay considerations.

The program first prints out the capacity values - arrival-priority, departure-priority, plus any intermediate points resulting from gap stretching - which were used to compute the resulting capacity. For each such point, the arrival and departure capacity at that point

are printed; for each intermediate point, the maximum "stretch" added to each gap is also printed.

Next, the program will print the means by which the specified arrival percentage is achieved. One of the following messages will be printed:

TO OBTAIN 100 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY 26.2 OPERATIONS PER HOUR

- the arrival-priority capacity contains an excess number of departures (no additional arrivals are possible)

TO OBTAIN 50 PERCENT ARRIVALS, OPERATE
AT POINT 1 FOR 76 PERCENT OF THE HOUR,
AND AT POINT 2 FOR 24 PERCENT

- point 1 (arrival-priority) contains an excess of arrivals, and point 2 (the first gap-stretching point) contains too few arrivals to satisfy the desired arrival percentage, so the program interpolates between them.

TO OBTAIN 75 PERCENT ARRIVALS, OPERATE
AT POINT 3 FOR 31 PERCENT OF THE HOUR, AND
AT DEPARTURE PRIORITY POINT FOR 69 PERCENT

- point 3 (the last gap-stretching point, in this case) contains more arrivals than required, so the program interpolates between this point and the departure priority point.

TO OBTAIN 0 PERCENT ARR, INTERFERING ARRIVAL STREAMS ARE ELIMINATED,
AND REMAINING ARRIVAL CAPACITY IS REDUCED BY 19.6 OPERATIONS PER HOUR

- even with departure-priority, some arrivals remain. These excess arrivals are dropped to achieve the desired arrival percentage.

If the desired arrival percentage is satisfied exactly at one of the capacity points, the message printed will be

ARRIVAL PRIORITY CONFIGURATION PROVIDES DESIRED PERCENT ARRIVALS

or similar.

This message is then followed by the airfield capacity at the desired percentage of arrivals.

Certain runway configuration will result in additional messages. For example, if alternating arrivals are being run, either

ALTERNATING APPROACHES -- x NMI DIAGONAL/y FT

or

ALTERNATING APPROACHES -- x NMI INTRAIL SEPARATION

will be printed, where x is the minimum separation in use and y is the distance between runway centerlines.

Also, certain intersecting runway configurations are evaluated with traffic on both runways and with all traffic on just one runway. The operating mode with the greater capacity is chosen, and the message is printed that "ARR ON #1, DEP ON #2 ... " or "MIXED, SINGLE RUNWAY PROVIDES GREATER CAPACITY."

Examples of the output format will be found in Section 2.8.

2.6 Running the Programs

To run the FAA Airfield Capacity Program, two input modes are possible:

- o Remote Job Entry (RJE) using cards
- o using an interactive terminal and stored input files.

Remote job entry (also called batch processing) requires that all data be punched on cards. Additional cards are required to load the capacity model and to identify the user for billing purposes. Output is directed to a remote printer.

In the terminal mode, the user can construct input files and run the program directly from his work area. The input format is exactly the same as with cards. Ouput may be returned to a printer or directly to the terminal, or both.

The terminal mode also makes interactive data entry possible. This method, which will be explained in Chapter 3, involves responding to specific questions as they are asked by the program.

Details of loading and executing the program will vary at different installations. However, we can illustrate a typical procedure using

the technique for the CDC system. In this system, the user merely enters at his terminal

```
-CAPRUN(FN = filename
```

where filename is the name of the input file. If a file named "filename" exists, it will be used as input to the program; output will be returned to the terminal. The input file may be created by direct entry from the terminal or by editing a previously existing file. If "filename" does not exist, the program will enter the interactive mode. The input file created from the answers to the interactive questions will be stored, after execution, under the name "filename". If the user does not want to save this file, the command

```
PURGE, filename
```

will erase the file.

The FAA Airfield Capacity Program has been written in a version of Fortran IV which is compatible with the Control Data Corporation (CDC) timesharing system. Minor changes might be needed to install the program on other systems, but all attempts have been made to keep such changes to a minimum.

For example, the CDC version of Fortran IV is known to differ from the IBM version in at least the following areas:

- o FORMAT statements for literal data
- o standard length of REAL variables
- o end-of-file condition on a READ statement.

The program consists of almost 3000 lines of source code, comprising 25 subroutines. The compiled version is also almost 3000 lines long on CDC (or about 3300 lines on an IBM system). To load and execute the program requires approximately an additional 200K bytes of memory.

2.7 Additional Information

This section presents some information, in tabular form, which might be useful to the person who wishes to run the Airfield Capacity Model.

2.7.1 Model/Strategy Combinations

The Capacity Model contains 13 different basic runway configurations, or models, as shown in Figure 2-1. Each of these models has a number

of operating strategies (from 3 to 26) associated with it as well. Each strategy corresponds to a particular pattern of arrival and departure usage of the available runways, and may contain some information about the runway geometry itself (such as spacing between parallel runways and direction of operation on non-parallel runways).

Table 2-2 presents all the model and strategy combinations currently supported by the Airfield Capacity Model. Certain assumptions have been made in developing these particular combinations:

- In all configurations with three runways (except intersecting), runways 1 and 2 are always close-spaced. The separation between runways 2 and 3 is specified by the strategy.

- The spacing between parallel runways 1 and 3 is assumed to be related to the spacing between runways 2 and 3, as follows:

Runways 2 and 3	Runways 1 and 3
700-2499 ft (close)	2500-4299 ft (medium)
2500-3499 ft (near)	3500-4299 ft (medium)
3500-4299 ft (medium)	4300 ft or more (far)
4300 ft or more (far)	4300 ft or more (far)

- In all four runway configurations, runways 1 and 2 and runways 3 and 4 are assumed to be close-spaced parallels.

- A radar environment is assumed. Two non-intersecting runways are therefore considered parallel if the angle between them is less than 15°. The variable IR is used in the program and in Table 2-2 to specify the degree of dependence between two non-intersecting runways, as follows:

IR	Angle	Distance Between Thresholds	Interpretation
0	<15°	700-2499 ft	close parallel
1	<15°	2500-4299 ft	medium parallel
2	<15°	4300 ft or more	far parallel
3	≥15°	greater than zero	non-parallel

Table 2-2 also indicates the manner in which the program calculates the arrival-priority capacity of each configuration. Most capacities are simply the total of the capacities of the individual runways, or groups of runways, within the configuration. "Primary equation"

TABLE 2-2

RUNWAY MODELS AND STRATEGIES

SINGLE RUNWAY

MODEL	WEATHER	CAPACITY
1-1 (A)	all	primary equation
1-2 (D)	all	primary equation
1-3 (B)	all	1-1(A) plus interleaved departures
1-4* (B)		1-3(B) with predetermined inter-arrival times

TWO PARALLEL RUNWAYS

2-1 (F:A,A)	all	1-1(A) + 1-1(A)
2-2 (F:A,D)	all	1-1(A) + 1-2(D)
2-3 (F:D,D)	all	1-2(D) + 1-2(D)
2-4 (F:B,A)	all	1-3(B) + 1-1(A)
2-5 (F:B,D)	all	1-3(B) + 1-2(D)
2-6 (F:B,B)	all	1-3(B) + 1-3(B)
2-7 (M:A,A)	VMC	1-1(A) + 1-1(A)
	MMC/IMC	dependent arrivals, no vortex
2-8 (M:A,D)	all	1-1(A) + 1-2(D)
2-9 (M:D,D)	all	1-2(D) + 1-2(D)
2-10 (M:B,A)	VMC	1-3(B) + 1-1(A)
	MMC/IMC	2-7(M:A,A) plus departures

C -- close (700-2499 ft)
N -- near (2500-3499 ft)
M -- medium (2500-4299 ft)
F -- far (4300 ft or more)

A -- arrivals only
D -- departures only
B -- both arrivals and departures

*new model, only called by model 3-5(N:A,D,B)

TABLE 2-2 (Cont.)

TWO PARALLEL RUNWAYS

MODEL	WEATHER	CAPACITY
2-11 (M:B,D)	all	1-3(B) + 1-2(D)
2-12 (M:B,B)	VMC	1-3(B) + 1-3(B)
	MMC/IMC	2-7(M:A,A) plus departures on both
2-13 (N:A,A)		see 2-7 (M:A,A)
2-14 (N:A,D)		see 2-8 (M:A,D)
2-15 (N:D,D)		see 2-9 (M:D,D)
2-16 (N:B,A)		see 2-10 (M:B,A)
2-17 (N:B,D)		see 2-11 (M:B,D)
2-18 (N:B,B)		see 2-12 (M:B,B)
2-19 (C:A,A)	VMC	independent arrivals with vortex
	MMC/IMC	1-1 (A1) with average mix
2-20 (C:A,D)	VMC/MMC	1-1(A) + 1-2(D)
	IMC	dual-lane primary equation--DUAL(1)
2-21 (C:D,D)	VMC	independent departures with vortex
	MMC/IMC	1-2(D1) with average mix
2-22 (C:B,A)	VMC	1-3(B) + 1-1(A) with vortex
	MMC	1-1(A2) + 1-2(D1)
	IMC	2-20(C:A2,D1)
2-23 (C:B,D)	VMC	1-3(B) + 1-2(D) with vortex
	MMC	1-1(A) + 1-2(D)
	IMC	2-20(C:A,D)
2-24 (C:B,B)	VMC	1-3(B) + 1-3(B) with vortex
	MMC	1-1(A) + 1-2(D)
	IMC	2-20(C:A,D)

TABLE 2-2 (Cont.)

THREE PARALLEL RUNWAYS

MODEL		WEATHER	CAPACITY
3-1	(C:B,B,B)	VMC	1-3(B) + 1-3(B) + 1-3(B) with vortex
		MMC/IMC	2-12(M:B1,B3)
3-2	(N:B,B,B)	VMC	2-24(C:B1,B2) + 1-3(B3)
		MMC	1-2(D2) + 2-10(M:B3,A1)
		IMC	3-5(N:A,D,B)
3-3	(M:B,B,B)	VMC	2-24(C:B1,B2) + 1-3(B3)
		MMC/IMC	2-20(C:A,D) + 1-3(B3)
3-4	(C:A,D,B)	VMC	1-1(A) + 2-23(C:B3,D2)
		MMC	1-2(D2) + 2-7(M:A1,A3)
		IMC	3-17(C:A,D,A)
3-5	(N:A,D,B)	VMC	1-1(A) + 1-2(D) + 1-3(B)
		MMC	2-10(M:B3,A1) + 1-2(D2)
		IMC	2-7(M:A1,A3) + D3 from 1-4(B3) + D2 from DUAL(2,A,D)*
3-6	(F:A,D,B)	all	2-20(C:A,D) + 1-3(B)
3-7	(N:B,B,A)	VMC	2-24(C:B,B) + 1-1(A3)
		MMC	2-7(M:A1,A3) + 1-2(D2)
		IMC	2-7(M:A1,A3) + D2 from DUAL(2,A,D)*

A2 -- Arrivals only on runway 2

D3 -- Departures only on runway 3

*new model -- dual-lane operations with alternating arrival inputs

TABLE 2-2 (Cont.)

THREE PARALLEL RUNWAYS

MODEL	WEATHER	CAPACITY
3-8 (F:B,B,A)	VMC	2-24(C:B,B) + 1-1(A3)
	MMC/IMC	2-20(C:A,D) + 1-1(A3)
3-9 (N:A,B,B)	VMC	2-22(C:B2,A1) + 1-3(B3)
	MMC	2-7(M:A1,A3) + 1-2(D2)
	IMC	3-5(N:A,D,B)
3-10 (F:A,B,B)	all	2-20(C:A,D) + 1-3(B3)
3-11 (M:B,A,D)	all	2-22(C:B,A) + 1-2(D3)
3-12 (F:B,A,D)	all	2-22(C:B,A) + 1-2(D3)
3-13 (M:D,A,B)	VMC	2-20(C:A2,D1) + 1-3(B3)
	MMC	2-10(M:B3,A2) + 1-2(D1)
	IMC	3-5(N:A2,D1,B3)
3-14 (F:D,A,B)	all	2-20(C:A2,D1) + 1-3(B3)
3-15 (M:A,D,A)	all	2-20(C:A,D) + 1-1(A3)
3-16 (F:A,D,A)	all	2-20(C:A,D) + 1-1(A3)
3-17 (C:A,D,A)	VMC	2-20(C:A,D) + 1-1(A3)
	MMC	2-7(M:A1,A3) + 1-2(D2)
	IMC	2-7(M:A1,A3) + D2 from DUAL(3,A,D)*
3-18 (C:D,A,B)	VMC	2-22(C:B3,A2) + 1-2(D1)
	MMC	2-9(M:D1,D3) + 1-1(A2)
	IMC	3-25(C:D,A,D)
3-19 (C:B,A,D)	all	see 3-18 (C:D3,A2,B1)
3-20 (C:A,B,B)	VMC	1-1(A1) + 1-3(B2) + 1-3(B3) with vortex
	MMC	2-7(M:A1,A3) + 1-2(D2)
	IMC	3-17(C:A,D,A)

*new model -- dual lane operations with alternating arrival input

TABLE 2-2 (Cont.)

THREE PARALLEL RUNWAYS

MODEL	WEATHER	CAPACITY
3-21 (C:B,B,A)	all	see 3-20(C:A3,B2,B1)
3-22 (C:A,D,D)	VMC/MMC	2-21(C:D2,D3) + 1-1(A1)
	IMC	2-8(M:A1,D3)
3-23 (M:A,D,D)	VMC/MMC	2-9(M:D2,D3) + 1-1(A1)
	IMC	2-20(C:A,D) + 1-2(D3)
3-24 (F:A,D,D)	VMC/MMC	2-3(F:D2,D3) + 1-1(A1)
	IMC	2-20(C:A,D,) + 1-2(D3)
3-25 (C:D,A,D)	VMC/MMC	2-3(F:D1,D3) + 1-1(A2)
	IMC	2-20 (C:A2,D1) + D3 from 2-20 (C:A2,D3)
3-26 (M:D,A,D)	VMC/MMC	1-2(D1) + 1-1(A2) + 1-2(D3)
	IMC	2-20(C:A2,D1) + 1-2(D3)
3-27 (F:D,A,D)	all	see 3-26 (M:D,A,D)
3-28 (C:D,D,D)	VMC	1-2(D1) + 1-2(D2) + 1-2(D3) with vortex
	MMC/IMC	2-9(M:D1,D3)
3-29 (M:D,D,D)	all	2-21(C:D,D) + 1-2(D3)

TABLE 2-2 (Cont.)

FOUR PARALLEL RUNWAYS

MODEL	WEATHER	CAPACITY
4-1 (M:D,A,D,A)	all	2-20(C:A2,D1) + 2-20(C:A4,D3)
4-2 (F:D,A,D,A)	all	see 4-1(M:D,A,D,A)
4-3 (M:A,D,D,A)	all	2-20(C:A,D) + 2-20(C:A4,D3)
4-4 (F:A,D,D,A)	all	see 4-3(M:A,D,D,A)
4-5 (M:A,D,D,B)	all	2-20(C:A,D) + 2-23(C:B4,D3)
4-6 (F:A,D,D,B)	all	see 4-5(M:A,D,D,B)
4-7 (M:D,A,D,B)	all	2-20(C:A2,D1) + 2-23(C:B4,D3)
4-8 (F:D,A,D,B)	all	see 4-7(M:D,A,D,B)
4-9 (M:B,A,A,D)	VMC	2-22(C:B,A) + 2-20(C:A3,D4)
	MMC/IMC	1-3(B1) + 2-20(C:A3,D4)
4-10 (F:B,A,A,D)	all	see 4-9 (M:B,A,A,D)
4-11 (M:B,A,D,A)	all	2-22(C:B,A) + 2-20(C:A4,D3)
4-12 (F:B,A,D,A)		see 4-11(M:B,A,D,A)
4-13 (M:B,B,A,D)	all	2-24(C:A,D) + 2-20(C:A3,D4)
4-14 (F:B,B,A,D)	all	see 4-13(M:B,B,A,D)
4-15 (M:B,A,D,B)	all	2-22(C:B,A) + 2-23(C:B4,D3)
4-16 (F:B,A,D,B)	all	see 4-15(M:B,A,D,B)
4-17 (M:B,B,A,B)	all	2-24(C:B,B) + 2-22(C:B4,A3)
4-18 (F:B,B,A,B)	all	see 4-17(M:B,B,A,B)
4-19 (M:B,B,B,B)	all	2-24(C:B,B) + 2-24(C:B3,B4)
4-20 (F:B,B,B,B)	all	see 4-19(M:B,B,B,B)
4-21 (M/F:D,A,D,D)	all	2-20(C:A2,D1) + 2-21(C:D3,D4)
4-22 (M/F:A,D,D,D)	all	2-20(C:A,D) + 2-21(C:D3,D4)
4-23 (F:D,A,A,D)	all	2-20(C:A2,D1) + 2-20(C:A3,D4)
4-24 (M/F:D,D,D,D)	all	2-21(C:D,D) + 2-21(C:D3,D4)
4-25 (M:D,A,A,D)	VMC	2-20(C:A2,D1) + 2-20(C:A3,D4)
	MMC	1-2(D) + 2-7(M:A2,A3) + 1-2(D4)
	IMC	2-7(M:A2,A3) + D1 from DUAL(2, A2,D1) + D4 from DUAL(2,A3,D4)*

TABLE 2-2 (Cont.)

TWO OPEN-V RUNWAYS

MODEL	WEATHER	IR	CAPACITY
5-1 (DV*:D,D)	all	0	2-21(C:D,D)
		>0	1-2(D1) + 1-2(D2)
5-2 (DV:A,D)	VMC/MMC	all	1-1(A1) + 1-2(D2)
	IMC	0	2-20(C:A,D)
		>0	1-1(A1) + 1-2(D2)
5-3 (DV:B,D)	VMC	0	2-23(C:B,D)
		>0	1-3(B1) + 1-2(D2)
	MMC/IMC	0	2-20(C:A,D)
		>0	1-3(B1) + 1-2(D2)
5-4 (CV*:D,A)	VMC/MMC	all	1-2(D1) + 1-1(A2)
	IMC	0	2-20(C:A2,D1)
		1,2	1-2(D1) + 1-1(A2)
		3	6-2(A2,D1)
5-5 (CV:B,A)	VMC	0	2-22(C:B,A)
		>0	1-3(B1) + 1-1(A2)
	MMC	0,3	1-2(D1) + 1-1(A2)
		1	2-10(M:B,A)
		2	1-3(B1) + 1-1(A2)
	IMC	0	2-20(C:A2,D1)
		1	2-10(M:B,A)
		2	1-3(B1) + 1-1(A2)
		3	6-2(A,D)

*DV - diverging
CV - converging

TABLE 2-2 (Cont.)

TWO INTERSECTING RUNWAYS

MODEL	WEATHER	CAPACITY
6-1 (D,D)	VMC/MMC	max [primary equation, 1-2(D) with average mix]
	IMC	1-2(D) with average mix
6-2 (A,D)	all	primary equation
6-3 (B,D)	all	max [6-2(A,D), 1-3(B)]

THREE INTERSECTING RUNWAYS

7-1 (C:A,D,D)	VMC	2-20(C:A,D)
	MMC/IMC	max [2-20(C:A,D), 6-2(A,D)]
7-2 (M:A,D,D)	all	2-8(M:A,D)
7-3 (C:B,B,D)	VMC	2-24(C:B,B)
	MMC/IMC	max [2-20(C:A,D), 6-2(A,D)]
7-4 (M:B,B,D)	all	2-12(M:B,B)

*DV - diverging

CV - converging

TABLE 2-2 (Cont.)

THREE OPEN-V RUNWAYS

MODEL	WEATHER	IR		CAPACITY
10-1 (DV*:B,A,D)	VMC	all		2-22(C:B,A) + 1-2(D3)
	MMC/IMC	0		3-25(C:D,A,D
		>0		2-20(C:A,D) + 1-2(D3)
10-2 (DV:B,B,D)	VMC	0		2-22(C:B,A) + 1-2(D3)
		>0		2-24(C:B,B) + 1-2(D3)
	MMC/IMC	all		see 10-1(DV:B,A,D)
10-3 (CV*:B,D,A)	VMC	all		2-23(C:B,D) + 1-1(A3)
	MMC	0		2-7(M:A1,A3) + 1-2(D2)
		1,2	d <	3500: 2-7(M:A1,A3) + 1-2(D2)
			d ≥	3500: 1-1(A1) + 1-2(D2) + 1-1(A3)
		3		2-21(C:D,D) + 1-1(A3)
	IMC	0		3-4(C:A,D,A)
		1,2	d <	3500: 3-7(N:A,D,A)
			d ≥	3500: 2-20(C:A,D) + 1-1(A3)
		3		2-20(C:A,D)
10-4 (CV:B,B,A)	VMC	all		2-24(C:B,B) + 1-1(A3)
	MMC/IMC	all		see 10-3(CV:B,D,A)
10-5 (DV:D,A,D)	VMC	all		2-20(C:A2,D1) + 1-2(D3)
	MMC/IMC	all		see 10-1(DV:B,A,D)

*DV - diverging
CV - converging

TABLE 2-2 (Cont.)

MODEL	WEATHER	IR	CAPACITY
FOUR OPEN-V RUNWAYS			
11-1 (DV*:A,A,D,D)	VMC	all	2-19(C:A,A) + 2-21(C:D3,D4)
	MMC	all	2-20(C:A2,D3), average mix
	IMC	0	2-20(C:A2,D3), average mix
		>0	1-1(A2) + 1-2(D3), average mix
11-2 (DV:B,B,D,D)	VMC	0	2-22(C:B,A) + 2-21(C:D3,D4)
		>0	2-24(C:B,B) + 2-21(C:D3,D4)
	MMC/IMC	all	2-20(C:A,D) + 2-21(C:D3,D4)
11-3 (CV*:A,A,D,D)	VMC	all	2-19(C:A,A) + 2-21(C:D3,D4)
	MMC	all	2-20(C:A3,D3), average mixes
	IMC	<3	2-19(C:A,A) + 2-21(C:D3,D4)
		3	6-2(A2,D3)
11-4 (CV:B,B,D,D)	all	all	see 11-3(CV:A,A,D,D)
TWO RUNWAYS INTERSECTING BEYOND			
12-1 (DV*:A,D)	VMC/MMC	all	1-1(A1) + 1-2(D2)
	IMC	0	2-20(C:A,D)
		>0	1-1(A1) + 1-2(D2)
12-2 (DV:B,D)	VMC	0	2-23(C:B,D)
		>0	1-3(B1) + 1-2(D2)
	MMC/IMC	0	2-20(C:A,D)
		0	1-3(B1) + 1-2(D2)
12-3 (CV*:D,A)	VMC/MMC	all	1-2(D1) + 1-1(A2)
	IMC	0	2-20(C:A2,D1)
		1,2	1-2(D1) + 1-1(A2)
		3	6-2(A2,D1)
12-4 (CV:B,A)	all	all	5-5(CV:B,A)

*DV - diverging
CV - converging

TABLE 2-2 (Cont.)

THREE RUNWAYS INTERSECTING BEYOND

MODEL	WEATHER	IR	CAPACITY
13-1 (DV*:B,A,D)	all	all	10-1(DV:B,A,D)
13-2 (DV:B,B,D)	all	all	10-2(DV:B,B,D)
13-3 (CV*:B,D,A)	all	all	10-3(CV:B,D,A)
13-4 (CV:B,B,A)	all	all	10-4(CV:B,B,A)

FOUR RUNWAYS INTERSECTING BEYOND

14-1 (DV*:A,A,D,D)	all	all	11-1(DV:A,A,D,D)
14-2 (DV:B,B,D,D)	all	all	11-2(DV:B,B,D,D)
14-3 (CV*:A,A,D,D)	VMC/MMC	all	11-3(CV:A,A,D,D)
	IMC	all	6-2(A1,D3)
14-4 (CV:B,B,D,D)	all	all	11-3(CV:A,A,D,D)

FOUR INTERSECTING RUNWAYS

15-1 (A,A,D,D)	VMC	2* [6-2(A2,D3) with altered inputs]
	MMC/IMC	6-2(A2,D3) with altered inputs
15-2 (B,B,D,D)	VMC	max [2* [6-2(A2,D3) with altered inputs], 2-24(C:B,B)]
	MMC/IMC	max [2-20(C:A,D), 6-2(A1,D4)]

*DV - diverging

CV - converging

means that the configuration cannot be simplified any further, and capacity is computed as described in Section 2.2.

2.7.2 Estimation of Runway Occupancy Times

If data on average arrival runway occupancy times is not readily available, it is possible to utilize Tables 2-3 and 2-4 to derive estimates of the actual values. Table 2-3 contains typical runway occupancy times, by aircraft class, for exits located at the specified distance down the runway. In Table 2-4, the cumulative probabilities of aircraft exiting by that point are given.

To use these tables, the average time associated with each exit is multiplied by the probability of using that exit, and the results are summed together to obtain the overall value for each aircraft class.

To illustrate, we will calculate the estimated occupancy time for a type C aircraft on a 9000 foot-long runway, with regular exits located 4000 ft and 6500 ft down the runway.

From Table 2-3 the exit times for these exits are 38s (at 4000 ft), 60s (6500 ft -- interpolating between the 6000 ft and 7000 ft values), and 82s (9000 ft -- the runway end).

Table 2-4 shows the cumulative probability of exiting by the specified distance. The probability of using a specific exit will be the difference between the cumulative probability for that exit and the cumulative probability for the previous exit. In the example, the probability of using the 4000 ft exit is 0.08, of the 6500 ft exit is 0.88 (0.96-0.08), and 0.04 for the runway end (1.00-0.96). The average occupancy time for the runway is therefore 59s (= 38 * 0.08 + 60 * 0.88 + 82 * 0.04).

2.8 Examples

The following examples illustrate the use of the FAA Airfield Capacity Model.

2.8.1 Example 1 -- Single Runway, General Aviation

Compute the saturation hourly capacity of a single runway general aviation airport for 30%, 50%, and 70% arrivals in VMC. The aircraft mix consists of 85%A and 15%B aircraft. There are no touch-and-go operations. Assume typical values for all other parameters; arrival-arrival and departure-departure separations are taken from FAA-EM-78-8A.

TABLE 2-3

ESTIMATED ARRIVAL RUNWAY OCCUPANCY TIME (Seconds)

DISTANCE THRESHOLD TO EXIT (000 ft)	WET RUNWAYS				DRY RUNWAYS							
					REGULAR EXITS				HIGH-SPEED EXITS			
	A	B	C	D	A	B	C	D	A	B	C	D
0	24	--	--	--	24	--	--	--	19	--	--	--
1	24	--	--	--	24	27	--	--	27	24	--	--
2	34	27	--	--	34	27	--	--	35	24	--	--
3	44	37	30	--	44	37	29	--	43	32	35	35
4	55	47	38	--	55	46	38	38	43	41	35	35
5	65	56	47	47	65	56	47	47	43	49	44	44
6	76	65	56	56	76	65	56	56	43	49	54	54
7	99	99	65	65	76	75	65	65	43	49	63	63
8	99	99	73	73	76	75	73	73	43	49	63	63
9	99	99	82	82	76	75	82	82	43	49	63	63
10	99	99	82	82	76	75	85	85	43	49	63	63
11	99	99	82	82	76	75	90	90	43	49	63	63

TABLE 2-4

CUMULATIVE PROBABILITY OF EXIT USAGE

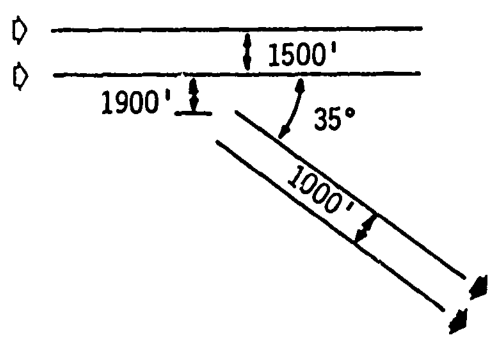
DISTANCE THRESHOLD TO EXIT (000 ft)	WET RUNWAYS				DRY RUNWAYS							
					REGULAR EXITS				HIGH-SPEED EXITS			
	A	B	C	D	A	B	C	D	A	B	C	D
0	0	0	0	0	0	0	0	0	0	0	0	0
1	4	0	0	0	6	0	0	0	13	0	0	0
2	60	0	0	0	84	1	0	0	90	1	0	0
3	96	10	0	0	100	39	0	0	100	40	0	0
4	100	80	1	0	100	98	8	0	100	98	26	3
5	100	100	12	0	100	100	49	9	100	100	75	55
6	100	100	48	10	100	100	92	71	100	100	98	95
7	100	100	88	64	100	100	100	98	100	100	100	100
8	100	100	100	93	100	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100	100	100	100	100	100
11	100	100	100	100	100	100	100	100	100	100	100	100

From Table 2-2 the runway use configuration is identified as Model 1-3(B). Figure 2-3 shows the input file for this example and the computer output.

The output indicates an arrival-priority capacity of 31.7 arrivals and 57.2 departures per hour and a departure-priority capacity of 102.9 departures. No intermediate points were specified. To obtain 30% arrivals, the program interpolates between these two points and obtains a total capacity of 90.8 operations per hour. At 50% and 70% arrivals, the arrival-priority mode provides more than enough departures; the excess are dropped.

2.8.2 Example 2 -- Four Runways, MMC

Compute the saturation hourly capacity of the runway configuration shown below, in MMC (Marginal Meteorological Conditions), for 50% arrivals. The aircraft mix consists of 3%A, 7%B, 70%C, and 20%D aircraft. There are no touch-and-go operations. Standard exits are located at 1500', 3000', 4000', 5500', 7000', and 10000' from the threshold for both runways 1 and 2. Assume typical values for all other parameters.



The computer input file for this case is shown in Figure 2-4. If average runway occupancy times are not shown, approximate values can be estimated or Tables 2-3 and 2-4 can be used, as explained in Section 2.7.2. From these tables, the following values are taken:

EXIT	TIME				PROBABILITY			
	A	B	C	D	A	B	C	D
1500'	29	--	--	--	.45	0	0	0
3000'	44	37	--	--	.55	.39	0	0
4000'	--	46	38	--	--	.59	.08	0
5500'	--	60	51	51	--	.02	.62	.40
7000'	--	--	65	65	--	--	.30	.58
10000'	--	--	--	85	--	--	--	.02

```
** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

NEWRUN 0 0 0       *               GA AIRPORT
   1   3   0
RUNWAY 1 1 0
0.850.150.0 0.0
ARBAR2 1 2 0
 32. 40. 51. 58.
DLTAIJ 0 4 0
 1.9 1.9 1.9 1 9 1.9 1.9 1.9 1.9 2.7 2.7 1.9 1.9 4.5 4.5 3.6 2.7
APPSPD 0 5 0
  80 100 130 140
DRBAR  0 6 0
  24  29  39  39
TD      0 7 0
  35  35  45  50  35  35  45  50  50  50  60  60 120 120 120  90
GAMA    0 8 0
   1   1   6   6
TGRBAR 0 9 0
 23. 22. 27. 27.
SIGMAS 019 0
  8. 18.  0.  7.  6.
OTHERS 020 1
0.050.05 0.0 5.03500 3.00.0   30  50


SINGLE RUNWAY MIXED OPERATIONS WITHOUT T & G

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
              TOTAL =   88.85  ARRIVALS =  31.66     DEPARTURES =  57.19


    DEPARTURE PRIORITY CAPACITY
              TOTAL =  102.86  ARRIVALS =   0.0      DEPARTURES = 102.86

TO OBTAIN  30 PERCENT ARRIVALS, OPERATE
         AT POINT   1 FOR  86 PERCENT OF THE HOUR, AND
         AT DEPARTURE PRIORITY POINT FOR  14 PERCENT

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =    90.8  ARRIVALS =   27.2  DEPARTURES =   63.6

        *****     *****     *****     *****     *****     *****


TO OBTAIN  50 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  25.5  OPERATIONS PER HOUR

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =    63.3  ARRIVALS =   31.7  DEPARTURES =   31.7

        *****     *****     *****     *****     *****     *****
```

FIGURE 2-3
EXAMPLE 1 — INPUT/OUTPUT

** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

```
NEWRUN 0 0 0        **    EXAMPLE 2
  14   1   0
RUNWAY 1 1 0
0.030.070.700.20
RUNWAY 2 1 0
0.030.070.700.20
RUNWAY 3 1 0
0.030.070.700.20
RUNWAY 4 1 0
0.030.070.700.20
ARBAR2 1 2 0
 37. 43. 54. 60.
ARBAR2 2 2 0
 37. 43. 54. 60.
DLTAIJ 0 4 0
 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 4.0 4.0 3.0 3.0 6.0 6.0 5.0 4.0
APPSPD 0 5 0
  95 120 130 140
DRBAR  0 6 0
  29  34  39  39
TD     0 7 0
  60  60  60  60  60  60  60  60  60  60  60  60 120 120 120  90
GAMA   0 8 0
   6   6   6   6
TGRBAR 0 9 0
 23. 22. 27. 27.
OPENVX 010 0
  351900 0.0 0.0
SIGMAS 019 0
  8. 18.  0.  0.  6.
OTHERS 020 1
0.050.05 2.0 2.5 800 3.00.0   50

FOUR INTER BEYOND, AWAY, ARR ON #1, #2, DEP ON #3, #4

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
             TOTAL =   78.45  ARRIVALS =  27.60     DEPARTURES =  50.85

TO OBTAIN  50 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  23.2  OPERATIONS PER HOUR

             ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    55.2  ARRIVALS =   27.6  DEPARTURES =   27.6

      *****    *****    *****    *****    *****    *****
```

FIGURE 2-4
EXAMPLE 2 — INPUT/OUTPUT

The resulting average runway occupancy times are 37, 43, 54, and 60 seconds for types A, B, C, and D, respectively.

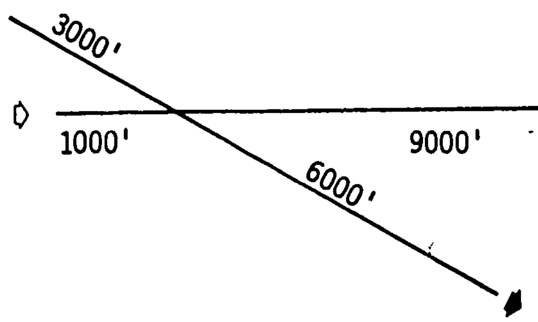
From Table 2-2, the runway use configuration is identified as Model 14-1 (DV:A,A,D,D) -- four runways intersecting beyond the threshold, diverging. Note in the input file that the aircraft mix must be entered for each runway, but the arrival occupancy times only for the arrival runways and the departure occupancy times are entered only once.

For this configuration (and for all open-V and "intersecting beyond the threshold" configurations) it was also necessary to input an OPENV line, containing the angle between runways and the distance between the non-parallel thresholds.

At 50% arrivals the capacity is 27.6 arrivals per hour and 27.6 departures. Actually, 50.9 departures are possible, but the excess are not needed.

2.8.3. Example 3 -- Intersecting Ruways, Different Aircraft Mixes

Compute the hourly capacity of the intersecting runway configuration shown below for 50% arrivals in IMC.



Compute capacity first for a mix of 60%C and 40%D aircraft, and then for a 75%C/25%D mix. Assume a future environment, according to FAA-EM-78-8A: 2.0 nmi basic arrival-arrival separation (2.5 nmi for a C following a D) and 60s between all departures. Assume typical values for all other parameters.

The runway configuration is Model 6-2 (A,D). The input file (Figure 2-5) contains all the information needed to compute capacity with both aircraft mixes: the capacity at 60%C/40%D is calculated first, and the results printed out (89.9 operations per hour), then the new mix is read in and the new capacity computed (90.6 operations).

```
** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

NEWRUN 0 0 0
   6   2   0
RUNWAY 1 1 0
0.0 0.0 0.600.40
RUNWAY 2 1 0
0.0 0.0 0.600.40
ARBAR2 1 2 0
 34. 34. 42. 45.
DLTAIJ 0 4 0
 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.5 2.5 2.0 2.0 3.0 3.0 2.5 2.0
APPSPD 0 5 0
  95 120 130 140
DRBAR   0 6 0
  29  34  39  39
TD      0 7 0
  60  60  60  60  60  60  60  60  60  60  60  60  60  60  60  60
GAMA    0 8 0
   6   6   6   6
TGRBAR 0 9 0
 23. 22. 27. 27.
ADSR    112 0
  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.
DICBR   013 0
 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0
SIGMAS 019 0
 4.  8.  0.  0.  0.
OTHERS 020 0
0.050.01 2.0 0.0   0 3.00.0   50
INCIAT 026 1
   1.050   2 20.

TWO INTERSECTING, ARR ON #1, DEP ON #2

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
              TOTAL =   90.10  ARRIVALS =  45.81    DEPARTURES =  44.30

    DEPARTURE PRIORITY CAPACITY
              TOTAL =   60.00  ARRIVALS =   0.0     DEPARTURES =  60.00

    CAPACITY AT POINT #  2                 MAX GAP STRETCH =  20. SEC
              TOTAL =   89.38  ARRIVALS =  43.17    DEPARTURES =  46.21

TO OBTAIN  50 PERCENT ARRIVALS, OPERATE
         AT POINT   1 FOR  66 PERCENT OF THE HOUR, AND
         AT POINT   2 FOR  34 PERCENT

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =    89.9  ARRIVALS =   44.9  DEPARTURES =   44.9

        *****    *****    *****    *****    *****    *****
```

FIGURE 2-5
EXAMPLE 3 — INPUT/OUTPUT

```
RUNWAY 1 1 0
0.0 0.0 0.750.25
RUNWAY 2 1 1
0.0 0.0 0.750.25

TWO INTERSECTING, ARR ON #1, DEP ON #2

    ARRIVAL PRIORITY CAPACITY   (POINT #1)
              TOTAL =   90.87  ARRIVALS =  46.25     DEPARTURES =  44.61

    DEPARTURE PRIORITY CAPACITY
              TOTAL =   60.00  ARRIVALS =   0.0      DEPARTURES =  60.00

    CAPACITY AT POINT #  2                 MAX GAP STRETCH =  20. SEC
              TOTAL =   90.25  ARRIVALS =  44.13     DEPARTURES =  46.12

TO OBTAIN  50 PERCENT ARRIVALS, OPERATE
         AT POINT   1 FOR  54 PERCENT OF THE HOUR, AND
         AT POINT   2 FOR  46 PERCENT

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =    90.6  ARRIVALS =   45.3  DEPARTURES =   45.3

        *****     *****     *****     *****     *****     *****
```

FIGURE 2-5
EXAMPLE 3 — INPUT/OUTPUT
(Cont.)

CHAPTER 3 -- ON-LINE AIRFIELD CAPACITY MODEL

3.1 Introduction

The On-line Airfield Capacity Model is an adaptation of the general analytic capacity model for determining runway capacity described in Chapter 2. It employs an interactive (question and answer) routine between the computer and a user at a remote terminal. The responses by the user to the program's questions are used to construct a complete file of input data. The computer automatically checks the input to determine if it is in a valid format (e.g., the aircraft mix percentages must sum to 100%), and requests that new data be entered if the original data are invalid. The output of the On-line Airfield Capacity Model is a summary of user supplied inputs and the calculated hourly capacity of the runways. The input file is saved and can be used by the Batch Version of the program.

To utilize the On-line Airfield Capacity Model to determine runway capacity, it is necessary to have a remote computer terminal and telephone connections with a computer service which offers the On-line Airfield Capacity Model. It is not necessary to understand the details of computer operations or the Batch Capacity Model described in Chapter 2. Each user must establish his own user identification code with the computer service and must pay for the computer time, connect time, storage cost and any other charge associated with his use of the model. For additional details on accessing the On-line Airfield Capacity Model, contact:

Mr. Anees Adil, AEM-100
Office of Systems Engineering Management
Federal Aviation Administration
800 Independence Avenue, S. W.
Washington, D. C. 20591

3.2 Discussion of Terms Used by the On-line Airfield Capacity Model

In order that the ramifications of some of the questions asked by the interactive program will be better understood, certain terms will be explained in this section. This will help the user to supply the appropriate answer. These terms are:

- Air Traffic Control System

- Weather Conditions

- Runway Use Configuration
- Aircraft Mix.

3.2.1 Air Traffic Control System

The On-line Airfield Capacity Model can model either current or future ATC systems, by using the appropriate values for the arrival-arrival separations, departure-departure separations, and control system error. Four standard ATC systems are available:

- Present
- Near-term
- Intermediate
- Far-term.

A brief description of these systems may be found in Table 3-1, which shows the explanatory message which is available from the interactive program. Additional information may be found in FAA-EM-78-8A, "Parameters of Future ATC Systems Relating to Airport Capacity/Delay."

If these standard ATC systems are inadequate, the user of the interactive version also has the option of directly specifying the interarrival separation (DLTAIJ) and the standard deviation of the interarrival times (SIGMAA).

3.2.2 Weather Conditions

Three different weather conditions are recognized by the interactive program. These are:

- VMC - Visual Meteorological Conditions
- MMC - Marginal Meteorological Conditions
- IMC - Instrument Meteorological Conditions.

The weather condition specified affects the separations used by the program and the ATC procedures which are assumed to be in effect.

TABLE 3-1

EXPLANATION OF ATC SYSTEM CODES

THE FOLLOWING ATC SCENARIOS REPRESENT FAA E & D PLANNING AS OF JANUARY, 1980, AS DESCRIBED IN FAA-EM-78-8A.

ATC CODE	TIME FRAME	DESCRIPTION
P	PRESENT	CURRENT ATC SYSTEM
N	NEAR-TERM	VAS, TERMINAL FLOW MANAGEMENT
I	INTERMEDIATE	WVAS, TERMINAL FLOW MANAGEMENT, REDUCED RUNWAY OCCUPANCY IN IMC
F	FAR-TERM	WVAS, ADVANCED TERMINAL FLOW MANAGEMENT FURTHER REDUCTIONS IN IMC RUNWAY OCCUPANCY

The differences between the weather conditions are summarized in Table 3-2. In VMC:

- o VFR (Visual Flight Rules) apply
- o Visual separations are assumed
- o Approaches to parallel runways are independent (except for any wake vortex effects) if the runways are separated by 700 feet or more.

MMC represents instrument conditions with some use of visual separations:

- o IFR (Instrument Flight Rules) apply
- o Approaches to parallel runways are independent only if they are separated by 4300 feet or more
- o Visual separations are used between arrivals and departures on the same or close parallel runways.

IMC represents full use of instrument procedures:

- o All IFR procedures used in MMC are in effect
- o A 2.0 nmi departure/arrival separation (DLTADA) is used for operations to a single runway or a close parallel pair (less than 2500' apart). This means that the departure cannot be released if the arrival is less than DLTADA from the threshold.

These IFR or VFR procedures are implemented in the program by changing the manner in which a particular runway use configuration is modeled. For example, mixed operations can be conducted on close parallel runways in VMC. In IMC, the program will implement the IFR restrictions on parallel arrival and departure operations by assigning all arrivals to one runway and all departures to the other. This process affects many of the runway use configurations in the model. Therefore, the user should specify the runway use configuration which most closely agrees with what can actually happen under the desired operating condition.

3.2.3 Runway Use Configuration

The On-line Airfield Capacity Model recognizes 52 different runway use configurations, with each runway configuration representing a unique combination of number of runways (from one to four), relative

TABLE 3-2

EXPLANATION OF WEATHER CONDITIONS

WEATHER		VISIBILITY* (STAT. MI.)	CEILING* (FEET)	OPERATIONAL IMPACT
VMC	VISUAL METEOROLOGICAL CONDITIONS	5.0	5000	VISUAL APPROACHES -- PARALLEL RUNWAYS >700' APART ARE INDEPENDENT
MMC	MARGINAL METEOROLOGICAL CONDITIONS	2.5	900	IFR SEPARATIONS APPLY BETWEEN ARRIVALS -- PARALLEL RUNWAYS <4300' APART HAVE DEPENDENT ARRIVAL OPERATIONS -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS >700' APART ARE INDEPENDENT BECAUSE VISUAL SEPARATIONS ARE APPLIED
IMC	INSTRUMENT METEOROLOGICAL CONDITIONS	0.0	0	ALL IFR PROCEDURES ARE IN EFFECT -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS <2500' APART ARE DEPENDENT

*THESE ARE VALUES WHICH ARE INPUT TO THE PROGRAM, NOT BREAKPOINTS BETWEEN WEATHER CONDITIONS

RUNWAY USE DIAGRAM	DIAG. NO	ADDITIONAL DATA
	1	
	2	S
	3	S
	4	S
	5	S
	6	S
	7	S
	8	S
	9	S
	10	S
	11	S
	12	S

RUNWAY USE DIAGRAM	DIAG NO.	ADDITIONAL DATA
	13	
	14	
	15	
	16	
	17	S
	18	
	19	
	20	
	21	
	22	-

RUNWAY USE DIAGRAM	DIAG. NO.	ADDITIONAL DATA
	23	X,X
	24	X,X
	52	X,X
	25	X,X,X,X
	26	X,X,X,X

LEGEND

◇ Indicates that an arrival (or landing) may occur on the runway indicated.

◆ Indicates that a departure (or takeoff) may occur on the runway indicated.

The lack of a symbol means that aircraft operations will not or cannot occur from the runway indicated

S Indicates a variable runway spacing (feet)

C Indicates runway spacing category 700 2499 feet

X Indicates distance from threshold to intersection (feet)

A Indicates the angle between nonparallel runways (degrees).

D Indicates distance from centerline of runway 1 to threshold of far nonparallel runway (feet).

M Indicates runway spacing over 3500 feet.

FIGURE 3-1
DIAGRAMS OF RUNWAY USE CONFIGURATIONS FOR ON-LINE CAPACITY MODEL

RUNWAY USE DIAGRAM	DIAG NO.	ADDITIONAL DATA	RUNWAY USE DIAGRAM	DIAG NO.	ADDITIONAL DATA	RUNWAY USE DIAGRAM	DIAG NO.	ADDITIONAL DATA
	27	S		36			44	D,A
	28	S		37			45	
	29			38			46	D,A
	30			39	D,A		47	
	31	D,A		40			48	
	32			41			49	
	33	D,A		42	D,A		50	D,A
	34			43			51	
	35	D,A						

FIGURE 3-1
DIAGRAMS OF RUNWAY USE CONFIGURATIONS FOR ON-LINE CAPACITY MODEL
(Cont.)

position, and use for arrivals, departures, or both. Figure 3-1 pictures the 52 configurations, along with the identifying number for each and the additional information required for some configurations. These additional data include the separation distance between parallel runways, the distance from threshold to intersection, the distance between the centerline of runway number one and the threshold of the far nonparallel runway, and the angle between nonparallel runways. All distances are in feet and the angle is in degrees.

If a particular runway use configuration is not included in Figure 3-1, it may be possible to divide the runway configuration into independent components. If a very small percent of the total arrivals or departures is expected to occur on a given runway, it may be realistic to omit it in the specification of runway configuration. These methods will often permit the runway configuration to be found in Figure 3-1.

A number of assumptions have been made in developing the runway use configurations in Figure 3-1:

- For all three runway configurations except intersecting, runways 1 and 2 are assumed to be close-spaced parallel (700 to 2500 feet apart). For three parallel runways, the separation between the outer pair is assumed to be related to the user-specified separation between runways 2 and 3 as follows:

S	C + S
700-2499 ft (close)	2500-4299 ft (medium)
2500-3499 ft (near)	3500-4299 ft (medium)
3500-4299 ft (medium)	4300 ft or more (far)
4300 ft or more (far)	4300 ft or more (far)

  where S is the user-input separation between runways 2 and 3,

  C + S is the separation between runways 1 and 3.

  Note that there is no difference in the operating characteristics of near- or medium-spaced runways -- the distinction is made here only to determine the spacing of the outer pair.

- For three intersecting runways, no operations occur on the crossing runway. The user should consider specifying one of the two parallel runway configurations instead.

- For four runway configurations, runways 1 and 2 and runways 3 and 4 are assumed to be close-spaced parallels. The separation between the inner parallel pair, 2 and 3, is assumed to be 2500 feet or greater.

3.2.4 Aircraft Mix

In general, unless there are specific constraints on certain aircraft types, it is advisable to use the same aircraft mix on each runway. This mix would represent the aircraft which use the airport over the course of an entire day.

If different mixes are used on each runway, the overall airport mix may not be preserved, and airport capacity may be overestimated. For example, a general aviation runway may be able to handle many more general aviation aircraft than are present. GA capacity may be greater than GA demand, but air carrier capacity may still be inadequate. To minimize the chance of misinterpreting the model results in some cases, independent runways should be analyzed separately, and demand/capacity comparisons should be made for each aircraft type separately.

If the demand of a particular aircraft type is greater than its capacity, it may be possible to adjust the mix on each runway to increase capacity. In general, a more homogeneous mix will produce a higher capacity.

3.3 Data Input

In this section, each question which may be asked by the interactive program will be presented and explained. Both long and short forms will be given. Table 3-3 summarizes the questions, expected answers, and possible error messages.

3.3.1 General Information

The following general points apply:

- Not all these questions will be asked in any single run because several questions are applicable only to certain runway configurations.

- Multiple input items may be separated by one or more blanks or a comma.

- Entering the wrong number of items will produce an error message and the question will be presented again.

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TABLE 3-3

ON-LINE VERSION INPUT AND ERROR MESSAGES

DATA REQUEST	SHORT FORM	APPLICABILITY	VALID INPUT	MESSAGE FOR INVALID DATA
DO YOU WANT AN EXPLANATION OF ATC SYSTEM CODES?	None	After accessing computer	1 to 3 yes or no answers	Any response other than "N" or "NO" is treated as a yes reply
ENTER ATC SYSTEM CODE (P / N / I / F)	ATC CODE	Always used	P, N, I, F, PX, NX, IX, or FX	ERR INCORRECT ATC SYSTEM
ENTER VMC, MMC (MARGINAL IMC), OR IMC	WEATHER	Always used	V, M or I	ERR WEATHER MUST BE VMC, IMC, OR MMC
ENTER LENGTH OF FINAL APPROACH (CLASS A B C D)- 4 VALUES	FINAL APPROACH (A B C D)	VMC only	Four integers	No special error message (see GENERAL ERROR MESSAGES)
ENTER LENGTH OF FINAL APPROACH, ALL CLASSES - 1 VALUE	FINAL APPROACH, ALL	MMC and IMC	One integer	No specific error message
ENTER RUNWAY USE DIAGRAM NUMBER (1-52)	R/W #	Always used	Integer 1 through 52	ERR RUNWAY USE DIAGRAM NUMBER MUST BE BETWEEN 1 & 52
ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D) FOR EACH PRINTED RUNWAY NUMBER 1- 2- 3- 4-	R/W MIX	For all runways in the runway use diagram	Four integers which sum to 100. If fifth entry is 'ALL' same mix will be used for all runways.	5TH PARAMETER IS NOT ACCEPTABLE UNLESS IT IS 'ALL', REENTER ERR MIX PERCENTAGE DOES NOT TOTAL 100 FOR RUNWAY #____ REENTER
ENTER APPROACH SPEEDS	SPEEDS	Always used	Four integers	No special error message
ENTER SEPARATION 'S' BETWEEN PARALLEL RUNWAYS (FEET)	SEPARATION S	Parallel runways	Integer less than 10000	No special error message
ARE ALTERNATING APPROACHES?	ALTERNATING?	Parallel runways, MMC or IMC, separation ≥3000 ft	yes or no reply	No special error message
ENTER DIAGONAL SEPARATION (NMI), AND EXTRA DISTANCE FLOWN TO RW2 (FT)	DIAG SEP & DIST TO RW 2	Parallel runways with alternating arrivals	Two integers	No special error message
ENTER DISTANCE 'X' BETWEEN THRESHOLD AND INTERSECTION FOR EACH PRINTED RUNWAY NUMBER (FEET) 1- 2- 3- 4-	THRESHOLD TO INTERSECTION X	Intersecting runways (models 23 through 26, plus 52), for each runway	Integer under 10000	ERR THRESHOLD TO INTERSECTION DISTANCE MUST BE AN INTEGER BETWEEN 0 & 9999
ARE AIRCRAFT AIRBORNE AT INTERSECTION?.	AIRBORNE INTER?	Intersecting runways	yes or no reply	No special error message
ENTER DISTANCE 'D' BETWEEN THE THRESHOLD RW1 AND FARTHEST RUNWAY (FEET)	THRESHOLD RW1 TO FARTHEST RW 'D'	R/W use diagram 31, 33, 35, 39, 42, 44, 46, 50	Integer	No special error message

TABLE 3-3

ON-LINE VERSION INPUT AND ERROR MESSAGES (Cont.)

DATA REQUEST	SHORT FORM	APPLICABILITY	VALID INPUT	MESSAGE FOR INVALID DATA
ENTER ANGLE 'A' BETWEEN NONPARALLEL RUNWAYS (DEGREES)	ANGLE A	R/w use diagram 31, 33, 35, 39, 42, 44, 46, 50	Integer from 1 to 90	ERR ANGLE MUST BE AN INTEGER BETWEEN 1 & 91
ENTER DLTAIJ (3, 5, OR 16 VALUES)	DLTAIJ	If 'X' suffix is added to ATC system code	3, 5 or 16 numbers. Need not be integers.	ERR INPUT CAN BE 3, 5, or 16 NUMBERS, ____ WERE INPUT
ENTER INTERARRIVAL SIGMA	SIGMA	If 'X' suffix is added to ATC system code	One number, need not be integer	No special error message
ENTER ARRIVAL PERCENTAGE (UP TO 11 VALUES)	ARRIVAL %	Always used	Up to 11 integers ≤ 100. First value may be 9999, 8888, or 7777.	ERR PERCENTAGE MUST BE AN INTEGER BETWEEN 1 & 100 NO. ____ WAS INCORRECT
ENTER TOUCH & GO PERCENTAGE	T&G %	VMC, r/w use diagram 1-5	Integer less than twice arrival percentage or twice departure percentage	ERR PERCENTAGE MUST BE AN INTEGER BETWEEN 1 & ____
ENTER AVERAGE OCCUPANCY TIMES BY CLASS, FOR EACH PRINTED RUNWAY NUMBER 1- 2- 3- 4-	EXIT TIMES	Always used. Number of runways based on r/w use diagram.	Four integers	EXIT TIME IS MINIMUM OF USER INPUT AND MAX VALUES: ____ (warning message, for I or F ATC systems. Max values are in FAA-EM-78-8A.)

GENERAL ERROR MESSAGES -- apply to all data requests

INVALID INPUT	COMPUTER RESPONSE
Blank input	WHAT ? ?
Too few inputs	Data request is repeated
Too many inputs	ERR A MAXIMUM OF ___ PARAMETERS ARE ALLOWED IN THIS QUESTION. . . ___ WERE INPUT
More than 16 inputs on a line	WHAT ? ?
Floating-point when integer is required	Data request is repeated
Character data (including negative sign) when integer is required	ERR I AM EXPECTING A NUMBER, NOT A LETTER OR WORD
Character data longer than 6 letters	ERR (____) ILLEGAL ANSWER OR NUMBER REENTER
HALT	RESTARTING PROGRAM. . . . DO YOU WISH TO PERFORM ANOTHER CALCULATION?

- o Execution may be halted at any time by entering 'HALT'. The user then may start over, or cancel the job.

- o The program assumes four aircraft classes (A, B, C, and D), with A being small aircraft (under 12,500 pounds),B and C being large aircraft (12,500 to 300,000 pounds), and D being heavies (over 300,000 pounds). All pertinent inputs are to be in this order.

3.3.2 Specific Questions

- DO YOU WANT AN EXPLANATION OF A T C SYSTEM CODES?

A YES or Y answer will print the message in Table 3-1, briefly describing the four standard ATC scenarios.

Two additional YES/NO answers are optional on this line. The first of these deals with question length; if this is NO (or N), the short form of the question will be printed. A final NO on this line will cancel the input summary usually printed after all the questions have been asked.

- ENTER ATC SYSTEM CODE (P / N / I / F)
- ATC CODE

Entry of one of the four code letters will result in standard values being used for arrival and departure separations, M&S performance, etc. The standard values are taken from FAA-EM-78-8A. The user may also input non-standard values for the arrival separation (DLTAIJ) and for the sigma of the interarrival time (SIGMAA). To do this, the user would add an 'X' to the ATC code otherwise chosen. For example, an entry of 'PX' would result in present-day values being used for departure separations and probabilities of violation, but DLTAIJ and SIGMAA would be user inputs, as described later.

- ENTER VMC, MMC (MARGINAL IMC), OR IMC
- WEATHER

One of three weather conditions is to be entered here. It is sufficient to enter just the first letter ('V,' 'M,' or 'I'). The ceilings and visibilities associated with each condition, and the effect of each condition on airport operation, are given in Table 3-2.

- ENTER LENGTH OF FINAL APPROACH, (CLASS A B C D) -- FOUR VALUES
- FINAL APPROACH (A B C D)

This message is printed only if VMC has been specified. Four numbers are to be entered, representing the final approach path length in nautical miles for each aircraft class.

- ENTER LENGTH OF FINAL APPROACH, ALL CLASSES -- ONE VALUE
- FINAL APPROACH, ALL

In MMC and IMC, all aircraft are assumed to fly the same final approach path. Consequently, only one number needs to be input in this response.

- ENTER RUNWAY USE DIAGRAM NUMBER (1-52)
- R/W #

The runway diagram number is obtained from Figure 3-1.

- ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D)
  FOR EACH PRINTED RUNWAY NUMBER
- R/W MIX

Four numbers, for the percentage of each aircraft class in the fleet mix, are to be entered in response to the runway number. Again, the model assumes a small/large/large/heavy mix. For multi-runway configurations, typing the word 'ALL' after the four percentages will result in the same fleet mix being used for all runways.

- ENTER APPROACH SPEEDS
- SPEEDS

The approach speeds for the four aircraft classes, in knots, are entered here. This speed is assumed to be constant from the start of the final approach path to the runway threshold. An average speed for this segment may be used.

- ENTER SEPARATION 'S' BETWEEN PARALLEL RUNWAYS
- SEPARATION S

For parallel runway configurations only, the distance in feet between the centerlines of runways 2 and 3 is requested. For three and four parallel runways, one or two runway pairs are assumed to be close spaced (700-2499 feet).

- RUN ALTERNATING APPROACHES?
- ALTERNATING?

In MMC, this question will be asked if the runway separation is large enough to allow alternating approaches. A 'Y' or 'N' answer is required.

- ENTER DIAGONAL SEPARATION (NMI), AND EXTRA DISTANCE FLOWN TO RW2 (FT)
- DIAG SEP & DIST TO RW2

The diagonal separation standard (2.0 nmi today) is the minimum spacing applied between alternating arrivals on parallel runways. The "extra distance flown" is a measure of the runway threshold displacement; a negative value would be entered if the runway 2 threshold were closer.

This question is only presented if a 'YES' answer was given to the previous question.

- ENTER DISTANCE 'X' BETWEEN THRESHOLD AND INTERSECTION FOR EACH PRINTED RUNWAY NUMBER (FEET)
- THRESHOLD TO INTERSECTION X

For intersecting runways only, the distance to the intersection is requested. This information is used to compute the times required for departures and arrivals to clear the intersection, which then determines ADSR and DICBR, the arrival-departure and departure-arrival separations.

- ARE AIRCRAFT AIRBORNE AT INTERSECTION?
- AIRBORNE INTER?

A 'Y' or 'N' answer is all that is needed for this question, asked only for intersecting configurations. The answer is used to determine whether to apply vortex separations at the intersection.

- ENTER DISTANCE 'D' BETWEEN THE THRESHOLD RW1
  AND FARTHEST RUNWAY (FEET)
- THRESHOLD RW1 TO FARTHEST RW 'D'

Asked for open-V and "intersecting beyond the threshold" configurations. The distance D is indicated on the diagrams in Figure 3-2.

- ENTER ANGLE 'A' BETWEEN NONPARALLEL RUNWAYS (DEGREES)
- ANGLE A

This question is similar to the previous one. The answers to these two questions are used to determine the degree of dependence between operations on the two runways.

- ENTER DLTAIJ (3, 5, OR 16 VALUES)
- DLTAIJ

If the user specified 'X' as part of the ATC code, this question and the next will be asked. For the arrival separation DLTAIJ, the user can enter 3, 5, or 16 numbers. Figure 3-2 shows how these values are arranged into the 4 X 4 separation matrix.

- ENTER INTERARRIVAL SIGMA
- SIGMAA

The value requested is the standard deviation of the interarrival time at the threshold, in seconds.

- ENTER ARRIVAL PERCENTAGE (UP TO 11 VALUES)
- ARRIVAL %

The percentage of arrivals in the total operations count is a required input. Up to 11 values can be entered. This limit was chosen to accommodate the case of zero to 100% by 10% increments.

The first value to be input could also be one of three special values: 9999, 8888, or 7777. These special values are explained in Chapter 2. If they appear elsewhere than in the first position, an error message will be returned.

o 3 NUMBER INPUT (1-3)

LEAD \ TRAIL	A	B	C	D
A	1	1	1	1
B	1	1	1	1
C	1	1	1	1
D	3	3	3	2

o 5 NUMBER INPUT (1-5)

LEAD \ TRAIL	A	B	C	D
A	1	1	1	1
B	4	1	1	1
C	4	1	1	1
D	5	3	3	2

o 16 NUMBER INPUT (1-16)

LEAD \ TRAIL	A	B	C	D
A	1	2	3	4
B	5	6	7	8
C	9	10	11	12
D	13	14	15	16

FIGURE 3-2
EXPANSION OF DLTAIJ MATRIX

- ENTER TOUCH & GO PERCENTAGE
- T & G %

If the weather is VMC, and the configuration is single, parallel, or open V, this question is asked. The value entered must be less than twice the first arrival percentage entered above, and less than twice the corresponding departure percentage.

- ENTER AVERAGE OCCUPANCY TIMES BY CLASS, FOR EACH PRINTED RUNWAY NUMBER
- EXIT TIMES

For all configurations, this question is asked. Four values are entered, one for each aircraft class. For immediate and far-term ATC, certain maximum values of occupancy time have been specified in FAA-EM-78-8A. If either the 'I' or 'F' code has been specified for ATC, the program will use the minimum of the user-specified values and these stored maximum values, and print a warning message to the user.

After these questions have been asked, a summary of the input items will be printed, unless the no-summary option was chosen. Capacity is then calculated.

The program next asks, 'DO YOU WISH TO PERFORM ANOTHER CALCULATION?'. If the answer is 'Y,' the interactive questions will be repeated, starting with 'ENTER ATC SYSTEM CODE.'

3.4 Output

The input data summary printed by the program includes the ATC system, weather, runway use diagram, and aircraft mix and type of operation for each runway. Other information may be contained as well, depending upon the configuration. This input summary is printed unless the program is instructed not to; it can serve as a permanent record of the inputs used for the calculation.

After this summary, a one-line description of the runway configuration is printed, followed by the capacity results. First printed is the arrival-priority capacity: the maximum number of arrivals possible, plus the number of departures which can be inserted between arrivals without disrupting the flow. This may be followed by the departure-priority capacity (the maximum number of departures, plus any arrivals to non-interferring runways) and the intermediate capacities, if these are required for the calculation.

The intermediate capacities represent cases where the gap between arrivals is "stretched" by a small increment in order to accommodate more departures.

The arrival and departure capacities at the specified arrival percentage(s) are then printed, along with a description of the means by which the particular percentage was attained: elimination of excess arrivals or departures, or by a specified mix of operating strategies.

After the capacity is printed out, the program asks 'DO YOU WISH TO PERFORM ANOTHER CALCULATION?' Any answer other than 'Y' or 'YES' will end the run.

The On-line Airfield Capacity Model prepares an input data file for each run which is then submitted to the Batch version of the program discussed in Chapter 2. The input file for the last (or only) case in each run is automatically saved and may be used for additional runs. For more details, see Section 2. An example of such an input file may be found in Section 3.6.4 where it can be compared with the terminal input which created it.

3.5 Sensitivity Analysis

The FAA Airfield Capacity Model has been designed to facilitate sensitivity analyses of runway configurations. Often such analyses take the form of determining the effect on capacity of varying the percentage of arrivals. It is possible to specify up to 11 different arrival percentages for a single run of the interactive version; the order in which these are specified is not important. For an example, see Section 3.6.4.

Other sensitivity analyses may involve varying the aircraft mix, the runway occupancy times, and so on. To vary these parameters, the user has two options:

- o Use the interactive version a multiple number of times, once for each variation, or
- o Use the interactive version once, for the basic case, and then modify the resulting batch input file. Several cases can be evaluated with each run of the batch version simply by appending the data for the items which vary to the end of the basic input file. For more information, refer to Section 2.4.

3.6 Examples

3.6.1 Example 1 -- Single Runway, IMC

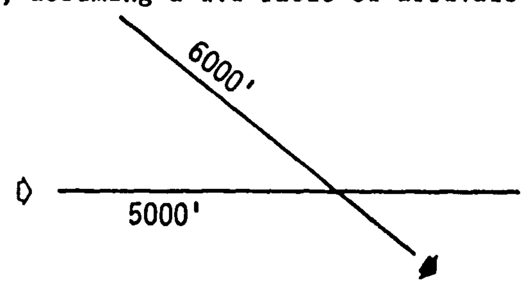
Determine the arrival-priority capacity of a single runway in IMC.

Aircraft Mix:	0%A, 5%B, 75%C, 20%D
Percent Arrivals:	9999 (arrival-priority)
Percent Touch-And-Go:	0
Runway Occupancy Times:	35, 42, 46, 51 seconds

Other inputs are standard. From Figure 3-1, runway configuration 1 is selected. The terminal session is shown in Figure 3-3. The computer output is in upper case, user input is lower case. Note the use of blanks and commas to separate input items, the input summary, and the form of the capacity output.

3.6.2 Example 2 -- Intersecting Runways, VMC

Determine the hourly capacity of the runway configuration shown below, in VMC, assuming a 1:1 ratio of arrivals to departures.



Aircraft Mix:	0%A, 5%B, 50%C, 45%D
Percent Arrivals:	50%
Percent Touch-And-Go:	0
Runway Occupancy:	30, 35, 40, 45 seconds

Arrival-Arrival Separations:

DLTAIJ:	2	2	2	2
	2	2	2	2
	2	2	2	2
	2	2	2	2

```
** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

*** AIRFIELD HOURLY CAPACITY MODEL***

DO YOU WANT AN EXPLANATION OF  A T C  SYSTEM CODES ?
no

ENTER ATC SYSTEM CODE ( P / N / I / F )
P

ENTER VMC, MMC (MARGINAL IMC), OR IMC
i

ENTER LENGTH OF FINAL APPROACH, ALL CLASSES
6

ENTER RUNWAY USE DIAGRAM NUMBER (1 - 52)
1

ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D)
FOR EACH PRINTED RUNWAY NUMBER
1-
0 5 75 20

ENTER APPROACH SPEEDS
95 120 130 140

ENTER ARRIVAL PERCENTAGE ( UP TO 11 VALUES)
9999

ENTER AVERAGE OCCUPANCY TIMES BY CLASS, FOR EACH
PRINTED RUNWAY NUMBER
1-
35,42, 46, 51

          *** INPUT SUMMARY ***

          PRESENT  ATC SYSTEM
          IMC  WEATHER
          RUNWAY USE DIAGRAM =    1
          PERCENT TOUCH + GO =    0
          PERCENT  ARRIVALS  =  9999

R/W    AIRCRAFT   MIX    TYPE
 #     (A)  (B)  (C)  (D)   OPN

 1      0.  5.  75.  20.    BOTH



SINGLE RUNWAY MIXED OPERATIONS WITHOUT T & G

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
             TOTAL =   54.58  ARRIVALS =  28.95     DEPARTURES =  25.63

DO YOU WISH TO PERFORM ANOTHER CALCULATION ?
no
```

FIGURE 3-3
EXAMPLE 1 — TERMINAL INPUT/OUTPUT

Sigma: 8 seconds

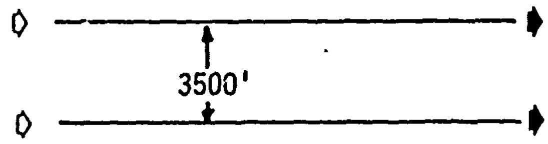
Approach Speeds: 95, 120, 130, 140 kn.

General aviation aircraft conduct short approaches (i.e., 2 nmi), all others use 6 nmi. From Figure 3-1, it is found that runway configuration 23 is appropriate.

Figure 3-4 shows the terminal dialogue. Note that an error was made on the final approach path lengths; the program was halted, and started over, to enter the proper values. Note also the error in the input aircraft mix and the resulting error message, also the user input of non-standard values.

3.6.3 Example 3 -- Parallel Runways, Alternating Arrivals

Determine the hourly capacity of the runway use shown below, in IMC, with 2.0 nmi diagonal separation between alternating arrivals.



Aircraft Mix: 0%A, 0%B, 50%C, 50%D

Percent Touch-And-Go: 0

Percent Arrivals: 60%

Runway Occupancy Times: 45, 48, 55, 63 seconds (Runway 1)
42, 47, 53, 60 seconds (Runway 2)

The runway use configuration is number 5, from Figure 3-1. In the program output (Figure 3-5), note that the input summary has been deleted, and extra input has been requested for the alternating arrival case. The capacity is 71 operations per hour.

3.6.4 Example 4 -- Parallel Runways, Sensitivity Analysis

Determine the sensitivity of hourly capacity to arrival percentage for the following case:

```
*** AIRFIELD HOURLY CAPACITY MODEL***

DO YOU WANT AN EXPLANATION OF  A T C  SYSTEM CODES ?
n n
ATC CODE
px
WEATHER
v
FINAL APPROACH (A B C D)
2 2 6 6
R/W #
halt

RESTARTING PROGRAM
DO YOU WISH TO PERFORM ANOTHER CALCULATION ?
yes

*** AIRFIELD HOURLY CAPACITY MODEL***

DO YOU WANT AN EXPLANATION OF  A T C  SYSTEM CODES ?
n n
ATC CODE
px
WEATHER
v
FINAL APPROACH (A B C D)
2 6 6 6
R/W #
23
R/W MIX
1-
0 5 70 45

ERR  MIX PERCENTAGE DOES NOT TOTAL 100 FOR RUNWAY # 1
REENTER
1-
0 5 50 45
2-
0 5 50 45
SPEEDS
95 120 130 140
THRESHOLD TO INTERSECTION X
1-
5000
2-
6000
AIRBORNE INTER ?
n
DLTAIJ
2 2 2
SIGMAA
8
ARRIVAL %
50
EXIT TIMES
1-
30 35 40 45
2-
30 35 40 45
```

FIGURE 3-4
EXAMPLE 2 — TERMINAL INPUT/OUTPUT

```
*** INPUT SUMMARY ***

PRESENT  ATC SYSTEM
VMC  WEATHER
RUNWAY USE DIAGRAM =  23
PERCENT TOUCH + GO =   0
PERCENT  ARRIVALS  =    50
DISTANCES BETWEEN THRESHOLDS AND INTERSECTION    5000    6000
DLT'IJ =  2.0 2.0 2.0 2.0
          2.0 2.0 2.0 2.0
          2.0 2.0 2.0 2.0
          2.0 2.0 2.0 2.0
SIGMAA =  8.00
PV     =  0.05


R/W     AIRCRAFT    MIX     TYPE
 #      (A)  (B)  (C)  (D)    OPN

 1       0.   5.  50.  45.    ARR
 2       0.   5.  50.  45.    DEP



TWO INTERSECTING, ARR ON #1, DEP ON #2

    ARRIVAL PRIORITY CAPACITY   (POINT #1)
             TOTAL =   63.25  ARRIVALS =  41.36     DEPARTURES =  21.89


    DEPARTURE PRIORITY CAPACITY
             TOTAL =   44.49  ARRIVALS =   0.0      DEPARTURES =  44.49


    CAPACITY AT POINT #  2                 MAX GAP STRETCH =  20. SEC
             TOTAL =   64.30  ARRIVALS =  35.44     DEPARTURES =  28.86



TO OBTAIN  50 PERCENT ARRIVALS, OPERATE
        AT POINT   2 FOR  87 PERCENT OF THE HOUR, AND
        AT DEPARTURE PRIORITY POINT FOR  13 PERCENT

             ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    61.7  ARRIVALS =   30.9  DEPARTURES =   30.9


      *****     *****     *****     *****     *****     *****


DO YOU WISH TO PERFORM ANOTHER CALCULATION ?
no
```

FIGURE 3-4
EXAMPLE 2 — TERMINAL INPUT/OUTPUT
(Cont.)

```
*** AIRFIELD HOURLY CAPACITY MODEL***

DO YOU WANT AN EXPLANATION OF  A T C  SYSTEM CODES ?
no yesy no

ENTER ATC SYSTEM CODE ( P / N / I / F )
P

ENTER VMC, MMC (MARGINAL IMC), OR IMC
i

ENTER LENGTH OF FINAL APPROACH, ALL CLASSES
5

ENTER RUNWAY USE DIAGRAM NUMBER (1 - 52)
5

ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D)
FOR EACH PRINTED RUNWAY NUMBER
1-
0,0,50,50,all

ENTER APPROACH SPEEDS
95,120,130,140

ENTER SEPARATION 'S' BETWEEN PARALLEL RUNWAYS (FEET)
3500

RUN ALTERNATING APPROACHES ?
yes

ENTER DIAGONAL SEPARATION (NMI), AND EXTRA DISTANCE FLOWN TO RW 2 (FT)
2 0

ENTER ARRIVAL PERCENTAGE ( UP TO 11 VALUES)
60

ENTER AVERAGE OCCUPANCY TIMES BY CLASS, FOR EACH
PRINTED RUNWAY NUMBER
1-
45,48,55,63
2-
42,47,53,60


*** ALTERNATING APPROACHES -- 2.0 NMI/ 3500. FT ***
TWO PARALLEL, MEDIUM, IMC, MIXED ON #1 AND #2

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
            TOTAL =   95.17  ARRIVALS =  42.70     DEPARTURES =  52.47

TO OBTAIN  60 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  24.0  OPERATIONS PER HOUR

            ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

            TOTAL =    71.2  ARRIVALS =   42.7  DEPARTURES =   28.5

      *****     *****     *****     *****     *****     *****
```

FIGURE 3-5
EXAMPLE 3 — TERMINAL INPUT/OUTPUT

Runway Configuration:	2
Weather:	VMC
Aircraft Mix:	10%A, 10%B, 50%C, 30%D
Runway Separation:	1000 feet
Percent Touch-And-Go:	0
Percentage Arrivals:	0, 35, 50, 65, 100%
Runway Occupancy:	45, 53, 53, 55 seconds (Runway 1) 42, 51, 55, 58 seconds (Runway 2).

Program output is shown in Figure 3-6. The short form of questioning was used.

The sensitivity of airfield capacity is found to be:

Arrival Percentage	Hourly Capacity
0%	49
35	76
50	69
65	53
100	35

The input file created by this terminal session is presented in Figure 3-7. A comparison reveals that some items reflect the user inputs, while others are standard values. For complete control over the parameters used in the capacity calculation, the user is urged to use the Batch Version of the program (see Chapter 2).

```
** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **


          *** AIRFIELD HOURLY CAPACITY MODEL***

DO YOU WANT AN EXPLANATION OF  A T C  SYSTEM CODES ?
n n n
ATC CODE
p
WEATHER
v
FINAL APPROACH (A B C D)
1 1 5 5
R/W #
2
R/W MIX
1-
10 10 50 30 all
SPEEDS
100 110 130 140
SEPARATION S
1000
ARRIVAL %
0,35,50,65,100
T & G  %
0
EXIT TIMES
1-
45 53 53 55
2-
42 51 55 58



TWO PARALLEL, CLOSE, VMC, ARR ON #1, DEPT ON #2

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
              TOTAL =   83.88  ARRIVALS =  34.73     DEPARTURES =  49.15


    DEPARTURE PRIORITY CAPACITY
              TOTAL =   49.15  ARRIVALS =   0.0      DEPARTURES =  49.15

DEPARTURE PRIORITY CONFIGURATION PROVIDES DESIRED PERCENT ARRIVALS


          ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

          TOTAL =    49.1  ARRIVALS =    0.0  DEPARTURES =   49.1

     *****     *****     *****     *****     *****     *****
```

FIGURE 3-6
EXAMPLE 4 — TERMINAL INPUT/OUTPUT

```
TO OBTAIN  35 PERCENT ARRIVALS, OPERATE
        AT POINT   1 FOR  76 PERCENT OF THE HOUR, AND
        AT DEPARTURE PRIORITY POINT FOR  24 PERCENT

             *** AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    75.6  ARRIVALS =   26.5  DEPARTURES =   49.1

      *****     *****     *****     *****     *****     *****

TO OBTAIN  50 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  14.4  OPERATIONS PER HOUR

             *** AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    69.5  ARRIVALS =   34.7  DEPARTURES =   34.7

      *****     *****     *****     *****     *****     *****

TO OBTAIN  65 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  30.4  OPERATIONS PER HOUR

             *** AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    53.4  ARRIVALS =   34.7  DEPARTURES =   18.7

      *****     *****     *****     *****     *****     *****

TO OBTAIN 100 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  49.1  OPERATIONS PER HOUR

             *** AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    34.7  ARRIVALS =   34.7  DEPARTURES =    0.0

      *****     *****     *****     *****     *****     *****

DO YOU WISH TO PERFORM ANOTHER CALCULATION ?
no
```

FIGURE 3-6
EXAMPLE 4 — TERMINAL INPUT/OUTPUT
(Cont.)

```
NEWRUN    0 0
   2  20    0
RUNWAY 1 1 0
0.100.100.500.30
RUNWAY 2 1 0
0.100.100.500.30
ARBAR2 1 2 0
 45. 53. 53. 55.
ARBAR2 2 2 0
 42. 51. 55. 58.
DLTAIJ    4 0
 1.9 1.9 1.9 1.9 2.7 1.9 1.9 1.9 2.7 1.9 1.9 1.9 4.5 3.6 3.6 2.7
APPSPD    5 0
 100 110 130 140
DRBAR     6 0
  34  34  39  39
TD        7 0
  35  45  45  50  50  60  60  60  50  60  60  60 120 120 120  90
GAMA      8 0
   1   1   5   5
TGRBAR    9 0
 23. 22. 27. 27.
SIGMAS   19 0
  8. 18.  0.  0.  6.
OTHERS   20 0
0.050.05 0.0 5.05000 3.00.0    0  35  50  65 100
INCIAT   26 0
   1 .05   2 20.
BDD      22 0
  0.  0.  0. 25.  0.  0.  0. 20.  0.  0.  0. 10. 25. 20. 10.  0.
BAA      24 0
  0.  0.  0. 25.  0.  0.  0. 20.  0.  0.  0. 10. 25. 20. 10.  0.
```

FIGURE 3-7
EXAMPLE 4 — INPUT FILE

CHAPTER 4. DELETED.

This chapter described an airport simulation model which is being improved. It is anticipated that the effort will be completed in 1981.

CHAPTER 5 - ANNUAL DELAY MODEL VERSION 1 - ANNUAL DELAY

5.1 Introduction

An analytic model has been developed to compute:

a) Total annual delay.

b) Average delay per aircraft over a year.

c) The distribution of aircraft delays over a year.

The Annual Delay Model automates the manual process for determining annual delay described in reference b. The Annual Delay Model computes the delay in representative hours and aggregates them into measures of annual delay according to their frequency of occurrence. In doing this the model considers fluctuations of:

a) Weather (IFR & VFR)
b) Runway use configuration
c) Hourly capacity
d) Hourly demand

5.2 Model Logic

The Annual Delay Model takes a specified annual demand and apportions it into representative hourly demands. This is done using three distributions of demand; i.e.

Week Group Distribution of Demand - PWEEK(i)
Day Group Distribution of Demand - PDAY(j)
Hourly Distribution of Demand - PHOUR(k)

A week group is a set of weeks (or fractions of a week) that have similar demand and weather charateristics. Monthly data can be entered as 4 and a fraction weeks; e.g., 31 days = 4.43 weeks. The week group distribution of demand provides the proportion of the annual demand that occurs in each week of a week group.

A day group is a set of days within a week that have similar demand characteristics. Each day of the week may be accounted for separately or days may be grouped together. The day group distribution of demand provides the proportion of the weekly demand that occurs in each day of a day group.

The hourly distribution of demand provides the proportion of the daily demand that occurs in each hour. The hourly demand for a representative hour of the year is given by:

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$$HD(i,j,k) = \frac{\text{ANNUAL DEMAND}}{NWEEK(i) \cdot PWEEK(i) \cdot NDAY(j) \cdot PDAY(j) \cdot PHOUR(k)}$$

where: HD(i,j,k) = hourly demand for week group i, day group j, and hour group k.

NWEEK(i) = number of weeks in each week group.

NDAY(j) = number of days in each day group.

The representative hourly demand may be further adjusted to account for demand restrictions imposed by weather conditions and/or runway use configuration.

Hourly capacities are input for each runway use configuration and weather category combination. Hourly delays are calculated for each representative hour of the year and weather category using the delay curves given in Figure 2-68 of reference b. The average delay per operation for the year is computed considering the frequency of occurance of each representative hour, each weather condition, and each runway use configuration.

NOTE: In calculating hourly delay, the model assumes that all capacity and demand values are for 50% arrival.

5.3 Input Format

The following general instructions apply to preparing inputs to the Annual Delay Model:

1. Data entry requires two types of cards; i.e.,

    Header Card; e.g., WEAPCT 8

    Data Card(s); e.g., 0.82 0.64
    0.18 0.36

    (NOTE: 8 is the data type number. See 7. below.)

2. There is no fixed sequence for groups of header/data cards except:

    a) the card containing KRUN and I-PRINT data must be the first card in the deck, and

    b) Data type 2; i.e., GROUPS, must precede data types 3, 4, 5, 6, 7, 8, 9, 10, 13, 14 and 15.

3. Unless otherwise noted on the form by decimal points, right justify numbers within the blocks shown on the coding form.

4. To execute a run, place a 1 in card column 14 of the header card for the last data group.

5. Multiple runs can be made with one stack of cards. Place replacement header/data cards after the execute card for the first complete run. This procedure is illustrated in example 1.

6. Any 10 letter title can be used in card columns 1-10 of the header card.

7.. On the header card:

cc	1-10	Title
cc	11-12	Data type number
cc	14	Execute command (i.e., 1)

8. The model can accommodate:

52 week groups
7 day groups
10 weather groups
10 runway use configurations

The coding form in this chapter is constructed for up to 12 week groups and two weather groups.

9. Enter annual demand as 325000 not 325,000 or 325K.

10. Whenever a proportion or ratio is called for, the input should be entered as a decimal; e.g., 0.017 not 1.7%.

11. Allowable values of Demand Profile Factor are 25, 30, 35, 40, 45 and 50.

A sample coding form with header labels and decimal points is shown in Figure 5-1. It is recommended that a similar form be used in preparing card inputs. The definitions of terms used in the coding form are given below:

TERM	DEFINITION
KRUN	The number of runs to be executed. The value of KRUN is equal to the number of occurance of a 1 in card column 14 of the header card.
I-PRINT	If I-PRINT = 1, the input data will be listed before the output is printed. If I-PRINT = 0, no input data will be listed.
ANNDEMAND	A header label used with annual demand dat
ANNDEM	The annual demand in operations per year.

GROUPS	A header label used with the specification of group data.
NDGPS	Number of day groups.
NWGPS	Number of week groups.
NWECON	Number of weather conditions.
NRWUSE	Number of runway use configurations.
WKPERCENT	A header label used with the proportion of total annual traffic that occurs in one week of each week group; e.g., if total annual traffic = 350000 and demand in 1 week of a week group = 7350, the proportion = 0.021.
WG1 thru WG12	Week group 1 thru 12.
WKNUMBER	A header label used with the number of weeks in each week group.
CAPACITY	A header label used with the hourly runway capacity for each runway use configuration and weather combination.
WE1	Weather group 1.
WE2	Weather group 2.
DPERCENT	A header label used with the proportion of weekly traffic that occurs in 1 day of each day group; e.g., if weekly traffic = 6000 operations and the demand in 1 day of a day group = 875, the proportion = 0.146.
DG1 thru DG7	Day groups 1 thru 7.
DAYNUMBER	A header label used with the number of days in each day group.
DEMANPCT	A header label used with weather group demand factors; i.e., the ratio of demand in each weather group to the demand in WE1.
WEAPCT	A header label used with the proportion of occurrence of each weather group in any given week group.
DEMPROFILE	A header label used with Demand Profile Factor.
DPF	Demand Profile Factor
RWYDEMPCT	A header label used with runway use configuration demand factor; i.e., the ratio of demand

for each runway use configuration to the demand for RU1.

RU1 thru RU10	Runway use configuration number 1 thru 10.
RUNID	A header label used with title information.
TITLE	Any 20 letter name identifying the run; e.g., NATIONAL 1987 CASE 3
HOURPCT	A header label used with the proportion of daily traffic in each hour; e.g., if the daily traffic = 800 and the demand in hour HR7 = 60, the proportion for HR7 = 0.075.
HR1 thru HR24	Hour 12:00 a.m. - 12:59 a.m. through 11:00 p.m. - 11:59 p.m.
FIGNUMS	A header label used with the figure numbers given in Figure 5-1.
JPRINT	If JPRINT = 1, the model will print the total daily delay in hours for each Month-Day-Weather-Runway Use Configuration combination. If JPRINT = 0 or blank, the total daily delay will not be printed.

5.4 Input Considerations

The following factors should be considered in preparing inputs to the Annual Delay Model:

a. The sequence in which week group proportions are entered is not important. However, they must be coordinated with the annual weather distribution.

b. The input weather distribution represents the proportion of the days where that weather condition exists all day. The proportion of the days which are WE1 or WE2 should not include weather conditions which occur during very low demand periods of the day; e.g., do not include in this proportion days during which the bad weather only occurs between 10:00 p.m. and 5:00 a.m.

c. The sequence in which day group proportions are entered has no impact on annual delay. The important data is the magnitude of the numbers. The Annual Delay Model assumes that every week of each month has the same daily demand distribution.

d. The sequence in which hourly proportions are entered is very important, if demand exceeds capacity for several consecutive hours for some runway use configuration/weather combination.

e. It is recommended that only runway use configurations that occur for at least 5% of a given weather condition be considered in the annual delay analysis.

f. The Demand Profile Factor is defined as the percent of the hourly demand that occurs in the peak 15 minutes. To consider the variations of the Demand Profile Factor from hour to hour, input the average Demand Profile Factor for the busy hours of the day.

g. Touch-and-go operations do not normally occur during busy hours at commercial airports. Touch-and-go operations should be excluded from the annual operations when determining annual delay for commercial airports. If touch-and-go operations are included as part of the input for a general aviation airport, the hourly capacities should be based on the same percent touch-and-go. The Annual Delay Model treats touch-and-go operations as one arrival and one departure. If a runway use configuration consists of one runway used exclusively for touch-and-go operations and one runway for arrival and departure operations, the annual delay analysis should be done separately for each runway.

5.5 Output

The output of the Annual Delay Model consists of:

a) total annual delay in hours

b) average delay per operation in minutes

c) standard deviation of average delay per operation in minutes

d) distribution of annual delay by:

month of year
day of week
weather condition
runway use configuration

e) frequency distribution of delay per operation

The frequency distribution of annual delay per operation is computed and listed by time interval. The output format is:

Time Interval		Percent of Operations	Cumulative Percent
0.0	0.2		
0.2	0.4		
.			
.			
.			
1.8	2.0		
2.0	3.0		
.			
.			
.			
99.0	100.0		
Over 100			

The time interval is not printed if it had 0% of the aircraft delays.

5.6 Optional Outputs

The Annual Delay Model can be used to calculate:

the delay for an hour,
the delay for a series of hours,
the delay for a day,
the delay for a week,
the delay for a month, and
measures of annual capacity.

The following defines procedures for determining these outputs:

a. Hourly Delay. The delay for a given hour can be determined by completing the partially filled in form shown in Figure 5-2. The value of annual demand should be equal to hourly demand x 365. Set HR1 = 1.0 for header label HOURPCT. The model output of average delay per operation is the average delay per operation for the hour under consideration.

b. Delay for a Series of Consecutive Hours. The delay for 2 or more consecutive hours up to 24 hours can be determined by completing the partially filled in form shown in Figure 5-2. The value of annual demand should be equal to the total hourly demand for the series of hours x 365.

The model output of average delay per operation is the average delay per operation over the time span considered.

c. Daily Delay. The average delay per operation for a day can be determined by following the procedure defined by b. above using an hourly demand distribution for the complete 24-hour period.

d. Weekly Delay. The average delay per operation for a particular week can be determined by computing the daily delay for the conditions specific to each day (or group of days) of the week.

e. Monthly Delay. The average delay per operation for a particular month can be determined by computing the daily delay for the conditions specific to each day (or group of days) of the month.

f. Measures of Annual Capacity. The Annual Delay Model can be used to determine a level of service of annual capacity based on:

1) The average delay per operation produced by a given number of annual operations.

2) The percent of annual operations having delays in excess of some selected delay per operation.

3) Some combination of the above.

The procedure is to operate the model at different values of annual operations but keeping all other inputs fixed. The model output can then be analyzed to determine annual capacity based on the level of service desired by the user.

5.7 Data Input Modes It is possible to use the Annual Delay Model in two input modes; i.e.,

- o Remote Job Entry (RJE) via cards
- o From a teletype terminal using stored files

Remote job entry requires that all data be punched on IBM cards and be processed by a card reader. Job cards are required to load the capacity model and to identify the user for billing purposes. Model output is printed on a remote printer.

In the teletype terminal mode the user can construct input files and call for model executions directly from the teletype location. The input format is exactly the same as with cards. To call for an execution, a series of computer instructions are entered from the teletype terminal. These instructions can be stored in the computer and called for by a Command File or CLIST. The FAA has established Command Files on TYMSHARE and McAuto for operation of the Annual Delay Model from a teletype terminal. To use this method requires that the input data be placed in a temporary file named BATCH.SUB and that the command EX TER AND be entered. The result will be a complete execution of the Annual Delay Model. After execution, the input file BATCH.SUB can be renamed and permanently stored, or edited and reexecuted.

5.8 Examples

The following examples illustrate the use of the Annual Delay Model Version 1.

Example 1

Compute the total delay for the following conditions:

Annual Demand: 300,000 and 400,000 operations
Percent Arrival: 50
Percent Touch-and-Go: 0
Demand Profile Factor: 35
WE1 = VFR

WE2 = IFR
WE2 Demand = 90% of WE1 demand
RU2 = 110% of RU1
RU3 = 110% of RU1

Annual Demand Distribution

January	.087	July	.081
February	.087	August	.080
March	.082	September	.082
April	.081	October	.087
May	.080	November	.088
June	.076	December	.089

Annual Weather Distribution

	WE1	WE2		WE1	WE2
January	1.00	0.00	July	.98	.02
February	.99	.01	August	.99	.01
March	.98	.02	September	.99	.01
April	.99	.01	October	1.00	0.00
May	.98	.02	November	1.00	0.00
June	.98	.02	December	1.00	0.00

Daily Demand Distribution

Monday	.15	Friday	.15
Tuesday	.13	Saturday	.14
Wednesday	.14	Sunday	.15
Thursday	.14		

Hourly Demand Distribution

0-1	0.59	6-7	0.32	12-13	4.32	18-19	9.80
1-2	0.47	7-8	2.50	13-14	5.18	19-20	10.66
2-3	0.23	8-9	8.63	14-15	3.77	20-21	6.86
3-4	0.17	9-10	7.13	15-16	4.18	21-22	2.91
4-5	0.08	10-11	3.34	16-17	7.84	22-23	1.66
5-6	0.12	11-12	6.01	17-18	12.21	23-24	1.02

Hourly Capacity Data in Weather Condition 1

Runway Use	Runway Geometry	Figure Number	Mix Index	Hourly Capacity	Percent Utilization
1	Single RW	2-3	140	52	10
2	Parallel RW	2-4	140	72	30
3	Parallel RW	2-9	140	95	60

Hourly Capacity Data in Weather Condition 2

Runway Use	Runway Geometry	Figure Number	Mix Index	Hourly Capacity	Percent Utilization
2	Parallel RW	2-44	160	60	70
1	Single RW	2-43	160	50	30

Figure 5-3 shows the coding form for this problem with input data filled in. From the computer output shown in Figure 5-4, the total delay is found to be:

Annual Demand (Operations)	Annual Delay (Hours)
300,000	27,532
400,000	148,000

The computer run for Example 1 is contained in Figure 5-5. The total delay is found to be:

Annual Demand (Operations)	Annual Delay (Hours)
300,000	32,764
400,000	153,227

Example 2

Compute the average delay per operation for the following day.

Hourly Demand Distribution

Hour	Demand	Proportion
0-1	2	0.003
1-2	1	0.002
2-3	0	0.000
3-4	0	0.000
4-5	0	0.000
5-6	3	0.005
6-7	10	0.015
7-8	30	0.045
8-9	40	0.061
9-10	45	0.068
10-11	40	0.061
11-12	30	0.045
12-13	30	0.045
13-14	25	0.038
14-15	45	0.068
15-16	60	0.091
16-17	65	0.099
17-18	55	0.083
18-19	45	0.068
19-20	50	0.076
20-21	30	0.046
21-22	30	0.046
22-23	20	0.030
23-24	3	0.005
TOTAL	659	1.000

Use the single runway IFR data in Example 1 for all other inputs.

Figure 5-5 shows the coding form for this problem with the input data filled in. From the computer output shown in Figure 5-6 the average daily delay per operation is 7.2 minutes.

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

FIGURE 5-1

1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60
k r u n	i-print	jprint									
R U N I D		1 6									
title											
A N N D E	M A N D	1									
ann dem											
D E M P R	O F I L E	1 2									
dpf											
G R O U P	S	2									
ndgps	nwgps	nwecon	nrwuse								
W K P E R	C E N T	3									
wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .
W K N U M	B E R	4									
wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
.	.	.	.	.	.	.	.	.	.	.	.
D P E R C	E N T	5									
dg1	dg2	dg3	dg4	dg5	dg6	dg7					
0 .	0 .	0 .	0 .	0 .	0 .	0 .					
D A Y N U	M B E R	6									
dg1	dg2	dg3	dg4	dg5	dg6	dg7					
H O U R P	C T	1 1									
hr1	hr2	hr3	hr4	hr5	hr6	hr7	hr8	hr9	hr10	hr11	hr12
0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .
hr13	hr14	hr15	hr16	hr17	hr18	hr19	hr20	hr21	hr22	hr23	hr24
0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

FIGURE 5-1

	W E A P C	T	8										
	wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12	
we1	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	
we2	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .	
	D E M A N	P C T	7										
	we1	we2											
	1 . 0	.											
	R W Y U S	E P C T	1 0										
	we1	we2											
ru1	0 .	0 .											
ru2	0 .	0 .											
ru3	0 .	0 .											
ru4	0 .	0 .											
ru5	0 .	0 .											
ru6	0 .	0 .											
ru7	0 .	0 .											
ru8	0 .	0 .											
ru9	0 .	0 .											
ru10	0 .	0 .											
	R W Y D E	M P C T	1 3										
	ru1	ru2	ru3	ru4	ru5	ru6	ru7	ru8	ru9	ru10			
	1 . 0	.	.	.	.	.	.	.	.	.			

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

FIGURE 5-1

	CAPAC	ITY	9
	we1	we2	
ru1			
ru2			
ru3			
ru4			
ru5			
ru6			
ru7			
ru8			
ru9			
ru10			
	MIX I	NDEX	14
ru1			
ru2			
ru3			
ru4			
ru5			
ru6			
ru7			
ru8			

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1 FIGURE 5-1

	1–5	6–10	11–15											
	we1	we2												
ru9														
ru10														
	F L G N	U M S	1 5											
	we1	we2												
ru1	2 -	2 -												
ru2	2 -	2 -												
ru3	2 -	2 -												
ru4	2 -	2 -												
ru5	2 -	2 -												
ru6	2 -	2 -												
ru7	2 -	2 -												
ru8	2 -	2 -												
ru9	2 -	2 -												
ru10	2 -	2 -												

CODING FORM FOR OPTIONAL USES OF THE ANNUAL DELAY MODEL VERSION 1

FIGURE 5-2

Columns: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65

Card	Fields
	krun (cols 1–5) · i-print (cols 6–10)
RUNID 16	title
ANNDEMAND 1	ann dem
DEMPROFILE 12	dpf
HOURPCT 11	hr1 0. · hr2 0. · hr3 0. · hr4 0. · hr5 0. · hr6 0. · hr7 0. · hr8 0. · hr9 0. · hr10 0. · hr11 0. · hr12 0.
	hr13 0. · hr14 0. · hr15 0. · hr16 0. · hr17 0. · hr18 0. · hr19 0. · hr20 0. · hr21 0. · hr22 0. · hr23 0. · hr24 0.
CAPACITY 9	wel .0 (rul)
MIX INDEX 14	wel (rul)
FIG NUMS 15	wel (rul)
GROUPS 2	ndgps 1 · nwgps 1 · nwecon 1 · nrwuse 1
WKPERCENT 3	wgl 1.0

CODING FORM FOR OPTIONAL USES OF THE ANNUAL DELAY MODEL VERSION 1 · FIGURE 5-2

Columns 1–10	Columns 11–13	Note	Value
WKNUMBER	4	wgl	52.0
DPERCENT	5	dgl	1.0
DAYNUMBER	6	dgl	365
WEAPCT	8	wgl	1.0
DEMANPCT	7	wel	1.0
RWYUSEPCT	10	wel	1.0
RWYDEMPCT	13	rul	1.0

wel

rul

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1 — COMPLETED CODING FORM FOR EXAMPLE 1 — FIGURE 5-3

krun	i-print
2	1

RUNID 16

title
EXAMPLE 1

ANNDEMAND 1

ann dem
400000

DEMPROFILE 12

dpf
35

GROUPS 2

ndgps	nwgps	nwecon	nrwuse
7	12	2	3

WKPERCENT 3

wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
0.019	0.022	0.018	0.019	0.018	0.018	0.018	0.018	0.019	0.020	0.021	0.020

WKNUMBER 4

wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
41.43	41.00	41.43	41.28	41.43	41.28	41.43	41.43	41.28	41.43	41.28	41.43

DPERCENT 5

dg1	dg2	dg3	dg4	dg5	dg6	dg7
0.15	0.13	0.14	0.14	0.15	0.14	0.15

DAYNUMBER 6

dg1	dg2	dg3	dg4	dg5	dg6	dg7
1	1	1	1	1	1	1

HOURPCT 11

hr1	hr2	hr3	hr4	hr5	hr6	hr7	hr8	hr9	hr10	hr11	hr12
0.006	0.005	0.002	0.002	0.001	0.001	0.003	0.025	0.036	0.071	0.033	0.060
hr13	**hr14**	**hr15**	**hr16**	**hr17**	**hr18**	**hr19**	**hr20**	**hr21**	**hr22**	**hr23**	**hr24**
0.043	0.052	0.038	0.042	0.078	0.122	0.098	0.117	0.069	0.029	0.017	0.010

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

COMPLETED CODING FORM FOR EXAMPLE 1

FIGURE 5-3

WEA PCT (8)

	wg1	wg2	wg3	wg4	wg5	wg6	wg7	wg8	wg9	wg10	wg11	wg12
we1	1.0	0.99	0.98	0.99	0.98	0.98	0.98	0.99	0.99	1.0	1.0	1.0
we2	0.0	0.01	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.0	0.0	0.0

DEMAN PCT (7)

we1	we2
1.0	0.9

RWY USE PCT (10)

	we1	we2
ru1	0.10	0.30
ru2	0.30	0.70
ru3	0.60	0.0
ru4	0.	0.
ru5	0.	0.
ru6	0.	0.
ru7	0.	0.
ru8	0.	0.
ru9	0.	0.
ru10	0.	0.

RWY DEM PCT (13)

ru1	ru2	ru3	ru4	ru5	ru6	ru7	ru8	ru9	ru10
1.0									

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1 COMPLETED CODING FORM FOR EXAMPLE 1 FIGURE 5-3

	CAPACITY we1	we2	9
ru1	52	50	
ru2	72	60	
ru3	95	0	
ru4			
ru5			
ru6			
ru7			
ru8			
ru9			
ru10			
	MIX INDEX		14
ru1	140	1.60	
ru2	140	1.60	
ru3			
ru4			
ru5			
ru6			
ru7			
ru8			

CODING FORM FOR ANNUAL DELAY MODEL VERSION 1

COMPLETED CODING FORM
FOR EXAMPLE 1

FIGURE 5-3

	Columns 1–5	Columns 6–10	Columns 11–15
	we1	we2	
ru9			
ru10			
	FIGN	UMS	1 5 1
	we1	we2	
ru1	2 -0 3	2 -4 3	
ru2	2 -0 4	2 -4 3	
ru3	2 -0 9	2 -	
ru4	2 -	2 -	
ru5	2 -	2 -	
ru6	2 -	2 -	
ru7	2 -	2 -	
ru8	2 -	2 -	
ru9	2 -	2 -	
ru10	2 -	2 -	
	ANNDE	MAND	1 1
	3 0 0	0.00	

CODING FORM FOR OPTIONAL USES OF THE ANNUAL DELAY MODEL VERSION 1 — COMPLETED CODING FORMS FOR EXAMPLE 2 — FIGURE 5-4

Columns 1–63

KRUN
k r u n	i-print
2	1

RUNID 16

title
EXAMPLE 2

ANNDEMAND 1

ann dem
240535

DEMPROFILE 12

dpf
35

HOURPCT 11

hr1	hr2	hr3	hr4	hr5	hr6	hr7	hr8	hr9	hr10	hr11	hr12
0.0013	0.0012	0.	0.	0.	0.0015	0.0115	0.0415	0.0611	0.0618	0.0611	0.0415

hr13	hr14	hr15	hr16	hr17	hr18	hr19	hr20	hr21	hr22	hr23	hr24
0.0415	0.0318	0.0618	0.0911	0.0920	0.0813	0.0648	0.0716	0.0416	0.0416	0.0310	0.0015

CAPACITY 9

	wel
rul	50.10

MIX INDEX 14

	wel
rul	1160

FIG NUMS 15

	wel
rul	21-413

GROUPS 2

ndgps	nwgps	nweccn	nrwucc
1	1	1	1

WKPERCENT 3

wgl
1.0

CODING FORM FOR OPTIONAL USES OF THE ANNUAL DELAY MODEL VERSION 1 — COMPLETED CODING FORMS FOR EXAMPLE 2 — FIGURE 5-4

Card columns 1–11	Columns 12–14
WKNUMBER	4
wgl: 52.0	
DPERCENT	5
dgl: 1.0	
DAYNUMBER	6
dgl: 365	
WEAPCT	8
wgl: 1.0 (wel)	
DEMANPCT	7
wel: 1.0	
RWYUSEPCT	10
wel: 1.0 (rul)	
RWYDEMPCT	13
rul: 1.0	

```
RUNID      16
EXAMPLE 1
ANNDEMAND  1
  300000
DEMPROFILE12
  35
GROUPS     2
    7   12     2     3
WKPERCENT  3
0.01960.02180.01850.01890.01810.01770.01830.01810.01910.01960.02050.0201
WKNUMBER   4
4.43004.00004.43004.29004.43004.29004.43004.43004.29004.43004.29004.4300
DPERCENT   5
0.15000.13000.14000.14000.15000.14000.1500
DAYNUMBER  6
    1     1     1     1     1     1     1
HOURPCT    11
0.00600.00500.00200.00200.00100.00100.00300.02500.08600.07100.03300.0600
0.04300.05200.03800.04200.07800.12200.09800.10700.06900.02900.01700.0100
WEAPCT     8
1.00000.99000.98000.99000.98000.98000.98000.99000.99001.00001.00001.0000
0.0    0.01000.02000.01000.02000.02000.02000.01000.01000.0    0.0    0.0
DEMANPCT   7
1.00000.9000
RWYUSEPCT 10
0.10000.3000
0.30000.7000
0.60000.0
RWYDEMPCT 13
1.00001.00001.0000
CAPACITY   9
 52.0 50.0
 72.0 60.0
 95.0  0.0
MIX INDEX 14
  140  160
  140  160
  140  160
FIG NUMS  15
 2- 3 2-43 2-
 2- 4 2-44 2-
 2- 9 2- 0 2-
```

```
*********************************
*   AIRPORT STUDY CONDITIONS    *
*      EXAMPLE 1                *
*********************************
```

COMPUTER RUN FOR EXAMPLE 1

ATCH ANNUAL DELAY MODEL VERSION 1, FEB 1977

```
ONTH= 1  DAY= 1  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  882.4  DAILY DELAY (HOURS )=  527.6
ONTH= 1  DAY= 1  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  882.4  DAILY DELAY (HOURS )=  129.9
ONTH= 1  DAY= 1  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  882.4  DAILY DELAY (HOURS )=   35.2
ONTH= 1  DAY= 1  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  794.2  DAILY DELAY (HOURS )=  423.3
ONTH= 1  DAY= 1  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  794.2  DAILY DELAY (HOURS )=  170.1
ONTH= 1  DAY= 2  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  764.8  DAILY DELAY (HOURS )=  340.9
ONTH= 1  DAY= 2  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  764.8  DAILY DELAY (HOURS )=   58.5
ONTH= 1  DAY= 2  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  764.8  DAILY DELAY (HOURS )=   13.1
ONTH= 1  DAY= 2  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  688.3  DAILY DELAY (HOURS )=  294.3
ONTH= 1  DAY= 2  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  688.3  DAILY DELAY (HOURS )=   74.7
ONTH= 1  DAY= 3  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  823.6  DAILY DELAY (HOURS )=  423.5
ONTH= 1  DAY= 3  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  823.6  DAILY DELAY (HOURS )=   90.3
ONTH= 1  DAY= 3  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  823.6  DAILY DELAY (HOURS )=   20.2
ONTH= 1  DAY= 3  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  741.2  DAILY DELAY (HOURS )=  344.8
ONTH= 1  DAY= 3  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  741.2  DAILY DELAY (HOURS )=  109.9
ONTH= 1  DAY= 4  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  823.6  DAILY DELAY (HOURS )=  423.5
ONTH= 1  DAY= 4  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  823.6  DAILY DELAY (HOURS )=   90.3
ONTH= 1  DAY= 4  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  823.6  DAILY DELAY (HOURS )=   20.2
ONTH= 1  DAY= 4  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  741.2  DAILY DELAY (HOURS )=  344.8
ONTH= 1  DAY= 4  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  741.2  DAILY DELAY (HOURS )=  109.9
ONTH= 1  DAY= 5  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  882.4  DAILY DELAY (HOURS )=  527.6
ONTH= 1  DAY= 5  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  882.4  DAILY DELAY (HOURS )=  129.9
ONTH= 1  DAY= 5  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  882.4  DAILY DELAY (HOURS )=   35.2
ONTH= 1  DAY= 5  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  794.2  DAILY DELAY (HOURS )=  423.3
ONTH= 1  DAY= 5  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  794.2  DAILY DELAY (HOURS )=  170.1
ONTH= 1  DAY= 6  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  823.6  DAILY DELAY (HOURS )=  423.5
ONTH= 1  DAY= 6  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  823.6  DAILY DELAY (HOURS )=   90.3
ONTH= 1  DAY= 6  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  823.6  DAILY DELAY (HOURS )=   20.2
ONTH= 1  DAY= 6  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  741.2  DAILY DELAY (HOURS )=  344.8
ONTH= 1  DAY= 6  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  741.2  DAILY DELAY (HOURS )=  109.9
ONTH= 1  DAY= 7  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  882.4  DAILY DELAY (HOURS )=  527.6
ONTH= 1  DAY= 7  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  882.4  DAILY DELAY (HOURS )=  129.9
ONTH= 1  DAY= 7  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  882.4  DAILY DELAY (HOURS )=   35.2
ONTH= 1  DAY= 7  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  794.2  DAILY DELAY (HOURS )=  423.3
ONTH= 1  DAY= 7  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  794.2  DAILY DELAY (HOURS )=  170.1
ONTH= 2  DAY= 1  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  981.5  DAILY DELAY (HOURS )= 1487.4
ONTH= 2  DAY= 1  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  981.5  DAILY DELAY (HOURS )=  241.6
ONTH= 2  DAY= 1  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  981.5  DAILY DELAY (HOURS )=   67.5
ONTH= 2  DAY= 1  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  883.3  DAILY DELAY (HOURS )=  654.7
ONTH= 2  DAY= 1  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  883.3  DAILY DELAY (HOURS )=  269.9
ONTH= 2  DAY= 2  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  850.6  DAILY DELAY (HOURS )=  469.7
ONTH= 2  DAY= 2  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  850.6  DAILY DELAY (HOURS )=  109.4
ONTH= 2  DAY= 2  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  850.6  DAILY DELAY (HOURS )=   23.5
ONTH= 2  DAY= 2  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  765.6  DAILY DELAY (HOURS )=  375.0
ONTH= 2  DAY= 2  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  765.6  DAILY DELAY (HOURS )=  128.0
ONTH= 2  DAY= 3  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  916.0  DAILY DELAY (HOURS )=  631.9
ONTH= 2  DAY= 3  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  916.0  DAILY DELAY (HOURS )=  153.5
ONTH= 2  DAY= 3  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  916.0  DAILY DELAY (HOURS )=   50.6
ONTH= 2  DAY= 3  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  824.4  DAILY DELAY (HOURS )=  475.7
ONTH= 2  DAY= 3  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  824.4  DAILY DELAY (HOURS )=  204.8
ONTH= 2  DAY= 4  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  916.0  DAILY DELAY (HOURS )=  631.9
ONTH= 2  DAY= 4  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  916.0  DAILY DELAY (HOURS )=  153.5
ONTH= 2  DAY= 4  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  916.0  DAILY DELAY (HOURS )=   50.6
ONTH= 2  DAY= 4  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  824.4  DAILY DELAY (HOURS )=  475.7
ONTH= 2  DAY= 4  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  824.4  DAILY DELAY (HOURS )=  204.8
ONTH= 2  DAY= 5  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  981.5  DAILY DELAY (HOURS )= 1487.4
ONTH= 2  DAY= 5  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  981.5  DAILY DELAY (HOURS )=  241.6
ONTH= 2  DAY= 5  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  981.5  DAILY DELAY (HOURS )=   67.5
ONTH= 2  DAY= 5  WEATHER= 2  RW CONF= 1  DAILY DEMAND=  883.3  DAILY DELAY (HOURS )=  654.7
ONTH= 2  DAY= 5  WEATHER= 2  RW CONF= 2  DAILY DEMAND=  883.3  DAILY DELAY (HOURS )=  269.9
ONTH= 2  DAY= 6  WEATHER= 1  RW CONF= 1  DAILY DEMAND=  916.0  DAILY DELAY (HOURS )=  631.9
ONTH= 2  DAY= 6  WEATHER= 1  RW CONF= 2  DAILY DEMAND=  916.0  DAILY DELAY (HOURS )=  153.5
ONTH= 2  DAY= 6  WEATHER= 1  RW CONF= 3  DAILY DEMAND=  916.0  DAILY DELAY (HOURS )=   50.6
```

```
ONTH=  2   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  824.4   DAILY DELAY (HOURS )=  475.7
ONTH=  2   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  824.4   DAILY DELAY (HOURS )=  204.8
ONTH=  2   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )= 1487.4
ONTH=  2   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )=  241.6
ONTH=  2   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  981.5   DAILY DELAY (HOURS )=   67.5
ONTH=  2   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  883.3   DAILY DELAY (HOURS )=  654.7
ONTH=  2   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  883.3   DAILY DELAY (HOURS )=  269.9
ONTH=  3   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=  443.4
ONTH=  3   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   95.5
ONTH=  3   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   21.3
ONTH=  3   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  354.9
ONTH=  3   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  115.5
ONTH=  3   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  721.9   DAILY DELAY (HOURS )=  303.8
ONTH=  3   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  721.9   DAILY DELAY (HOURS )=   48.7
ONTH=  3   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  721.9   DAILY DELAY (HOURS )=    9.9
ONTH=  3   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  649.7   DAILY DELAY (HOURS )=  230.2
ONTH=  3   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  649.7   DAILY DELAY (HOURS )=   53.7
ONTH=  3   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=  356.1
ONTH=  3   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   65.0
ONTH=  3   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   14.3
ONTH=  3   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=  304.5
ONTH=  3   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=   81.0
ONTH=  3   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=  356.1
ONTH=  3   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   65.0
ONTH=  3   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   14.3
ONTH=  3   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=  304.5
ONTH=  3   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=   81.0
ONTH=  3   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=  443.4
ONTH=  3   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   95.5
ONTH=  3   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   21.3
ONTH=  3   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  354.9
ONTH=  3   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  115.5
ONTH=  3   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=  356.1
ONTH=  3   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   65.0
ONTH=  3   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  777.4   DAILY DELAY (HOURS )=   14.3
ONTH=  3   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=  304.5
ONTH=  3   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  699.6   DAILY DELAY (HOURS )=   81.0
ONTH=  3   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=  443.4
ONTH=  3   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   95.5
ONTH=  3   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  832.9   DAILY DELAY (HOURS )=   21.3
ONTH=  3   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  354.9
ONTH=  3   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  749.6   DAILY DELAY (HOURS )=  115.5
ONTH=  4   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=  470.2
ONTH=  4   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=  109.6
ONTH=  4   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=   23.6
ONTH=  4   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  765.8   DAILY DELAY (HOURS )=  375.3
ONTH=  4   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  765.8   DAILY DELAY (HOURS )=  128.2
ONTH=  4   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  737.5   DAILY DELAY (HOURS )=  318.7
ONTH=  4   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  737.5   DAILY DELAY (HOURS )=   45.6
ONTH=  4   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  737.5   DAILY DELAY (HOURS )=   10.9
ONTH=  4   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  663.7   DAILY DELAY (HOURS )=  255.8
ONTH=  4   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  663.7   DAILY DELAY (HOURS )=   61.1
ONTH=  4   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  375.6
ONTH=  4   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=   73.9
ONTH=  4   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=   17.1
ONTH=  4   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  714.8   DAILY DELAY (HOURS )=  317.0
ONTH=  4   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  714.8   DAILY DELAY (HOURS )=   92.8
ONTH=  4   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  375.6
ONTH=  4   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=   73.9
ONTH=  4   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=   17.1
ONTH=  4   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  714.8   DAILY DELAY (HOURS )=  317.0
ONTH=  4   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  714.8   DAILY DELAY (HOURS )=   92.8
ONTH=  4   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=  470.2
ONTH=  4   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=  109.6
ONTH=  4   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND=  850.9   DAILY DELAY (HOURS )=   23.6
ONTH=  4   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND=  765.8   DAILY DELAY (HOURS )=  375.3
ONTH=  4   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND=  765.8   DAILY DELAY (HOURS )=  128.2
ONTH=  4   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND=  794.2   DAILY DELAY (HOURS )=  375.6
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ONTH=  4   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 794.2   DAILY DELAY (HOURS )=  73.9
ONTH=  4   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 794.2   DAILY DELAY (HOURS )=  17.1
ONTH=  4   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 714.8   DAILY DELAY (HOURS )= 317.0
ONTH=  4   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 714.8   DAILY DELAY (HOURS )=  92.8
ONTH=  4   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 850.9   DAILY DELAY (HOURS )= 470.2
ONTH=  4   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 850.9   DAILY DELAY (HOURS )= 109.6
ONTH=  4   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 850.9   DAILY DELAY (HOURS )=  23.6
ONTH=  4   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 765.8   DAILY DELAY (HOURS )= 375.3
ONTH=  4   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 765.8   DAILY DELAY (HOURS )= 128.2
ONTH=  5   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )= 403.4
ONTH=  5   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  85.3
ONTH=  5   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  19.2
ONTH=  5   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 335.8
ONTH=  5   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 104.7
ONTH=  5   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 706.2   DAILY DELAY (HOURS )= 272.5
ONTH=  5   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 706.2   DAILY DELAY (HOURS )=  41.9
ONTH=  5   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 706.2   DAILY DELAY (HOURS )=   8.9
ONTH=  5   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 635.6   DAILY DELAY (HOURS )= 179.3
ONTH=  5   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 635.6   DAILY DELAY (HOURS )=  46.6
ONTH=  5   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )= 335.9
ONTH=  5   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  56.4
ONTH=  5   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  12.7
ONTH=  5   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )= 291.0
ONTH=  5   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )=  72.5
ONTH=  5   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )= 335.9
ONTH=  5   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  56.4
ONTH=  5   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  12.7
ONTH=  5   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )= 291.0
ONTH=  5   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )=  72.5
ONTH=  5   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )= 403.4
ONTH=  5   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  85.3
ONTH=  5   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  19.2
ONTH=  5   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 335.8
ONTH=  5   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 104.7
ONTH=  5   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )= 335.9
ONTH=  5   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  56.4
ONTH=  5   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 760.6   DAILY DELAY (HOURS )=  12.7
ONTH=  5   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )= 291.0
ONTH=  5   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 684.5   DAILY DELAY (HOURS )=  72.5
ONTH=  5   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )= 403.4
ONTH=  5   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  85.3
ONTH=  5   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 814.9   DAILY DELAY (HOURS )=  19.2
ONTH=  5   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 335.8
ONTH=  5   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 733.4   DAILY DELAY (HOURS )= 104.7
ONTH=  6   DAY= 1   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 796.9   DAILY DELAY (HOURS )= 379.2
ONTH=  6   DAY= 1   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 796.9   DAILY DELAY (HOURS )=  75.3
ONTH=  6   DAY= 1   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 796.9   DAILY DELAY (HOURS )=  17.4
ONTH=  6   DAY= 1   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 717.2   DAILY DELAY (HOURS )= 319.4
ONTH=  6   DAY= 1   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 717.2   DAILY DELAY (HOURS )=  94.3
ONTH=  6   DAY= 2   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 690.6   DAILY DELAY (HOURS )= 233.6
ONTH=  6   DAY= 2   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 690.6   DAILY DELAY (HOURS )=  35.4
ONTH=  6   DAY= 2   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 690.6   DAILY DELAY (HOURS )=   8.0
ONTH=  6   DAY= 2   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 621.6   DAILY DELAY (HOURS )= 161.8
ONTH=  6   DAY= 2   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 621.6   DAILY DELAY (HOURS )=  40.0
ONTH=  6   DAY= 3   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 743.8   DAILY DELAY (HOURS )= 325.3
ONTH=  6   DAY= 3   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 743.8   DAILY DELAY (HOURS )=  48.5
ONTH=  6   DAY= 3   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 743.8   DAILY DELAY (HOURS )=  11.4
ONTH=  6   DAY= 3   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 669.4   DAILY DELAY (HOURS )= 266.2
ONTH=  6   DAY= 3   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 669.4   DAILY DELAY (HOURS )=  64.1
ONTH=  6   DAY= 4   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 743.8   DAILY DELAY (HOURS )= 325.3
ONTH=  6   DAY= 4   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 743.8   DAILY DELAY (HOURS )=  48.5
ONTH=  6   DAY= 4   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 743.8   DAILY DELAY (HOURS )=  11.4
ONTH=  6   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 669.4   DAILY DELAY (HOURS )= 266.2
ONTH=  6   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 669.4   DAILY DELAY (HOURS )=  64.1
ONTH=  6   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 796.9   DAILY DELAY (HOURS )= 379.2
ONTH=  6   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 796.9   DAILY DELAY (HOURS )=  75.3
ONTH=  6   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 796.9   DAILY DELAY (HOURS )=  17.4
ONTH=  6   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 717.2   DAILY DELAY (HOURS )= 319.4
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ONTH= 6  DAY= 5  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 717.2  DAILY DELAY (HOURS )=  94.3
ONTH= 6  DAY= 6  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 743.8  DAILY DELAY (HOURS )= 325.3
ONTH= 6  DAY= 6  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 743.8  DAILY DELAY (HOURS )=  48.5
ONTH= 6  DAY= 6  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 743.8  DAILY DELAY (HOURS )=  11.4
ONTH= 6  DAY= 6  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 669.4  DAILY DELAY (HOURS )= 266.2
ONTH= 6  DAY= 6  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 669.4  DAILY DELAY (HOURS )=  64.1
ONTH= 6  DAY= 7  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 796.9  DAILY DELAY (HOURS )= 379.2
ONTH= 6  DAY= 7  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 796.9  DAILY DELAY (HOURS )=  75.3
ONTH= 6  DAY= 7  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 796.9  DAILY DELAY (HOURS )=  17.4
ONTH= 6  DAY= 7  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 717.2  DAILY DELAY (HOURS )= 319.4
ONTH= 6  DAY= 7  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 717.2  DAILY DELAY (HOURS )=  94.3
ONTH= 7  DAY= 1  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 823.9  DAILY DELAY (HOURS )= 423.9
ONTH= 7  DAY= 1  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 823.9  DAILY DELAY (HOURS )=  90.4
ONTH= 7  DAY= 1  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 823.9  DAILY DELAY (HOURS )=  20.2
ONTH= 7  DAY= 1  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 741.5  DAILY DELAY (HOURS )= 345.2
ONTH= 7  DAY= 1  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 741.5  DAILY DELAY (HOURS )= 110.0
ONTH= 7  DAY= 2  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 714.0  DAILY DELAY (HOURS )= 290.8
ONTH= 7  DAY= 2  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 714.0  DAILY DELAY (HOURS )=  45.3
ONTH= 7  DAY= 2  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 714.0  DAILY DELAY (HOURS )=   9.4
ONTH= 7  DAY= 2  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 642.6  DAILY DELAY (HOURS )= 219.0
ONTH= 7  DAY= 2  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 642.6  DAILY DELAY (HOURS )=  50.1
ONTH= 7  DAY= 3  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 769.0  DAILY DELAY (HOURS )= 345.9
ONTH= 7  DAY= 3  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 769.0  DAILY DELAY (HOURS )=  60.6
ONTH= 7  DAY= 3  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 769.0  DAILY DELAY (HOURS )=  13.5
ONTH= 7  DAY= 3  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 692.1  DAILY DELAY (HOURS )= 297.7
ONTH= 7  DAY= 3  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 692.1  DAILY DELAY (HOURS )=  76.7
ONTH= 7  DAY= 4  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 769.0  DAILY DELAY (HOURS )= 345.9
ONTH= 7  DAY= 4  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 769.0  DAILY DELAY (HOURS )=  60.6
ONTH= 7  DAY= 4  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 769.0  DAILY DELAY (HOURS )=  13.5
ONTH= 7  DAY= 4  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 692.1  DAILY DELAY (HOURS )= 297.7
ONTH= 7  DAY= 4  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 692.1  DAILY DELAY (HOURS )=  76.7
ONTH= 7  DAY= 5  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 823.9  DAILY DELAY (HOURS )= 423.9
ONTH= 7  DAY= 5  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 823.9  DAILY DELAY (HOURS )=  90.4
ONTH= 7  DAY= 5  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 823.9  DAILY DELAY (HOURS )=  20.2
ONTH= 7  DAY= 5  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 741.5  DAILY DELAY (HOURS )= 345.2
ONTH= 7  DAY= 5  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 741.5  DAILY DELAY (HOURS )= 110.0
ONTH= 7  DAY= 6  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 769.0  DAILY DELAY (HOURS )= 345.9
ONTH= 7  DAY= 6  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 769.0  DAILY DELAY (HOURS )=  60.6
ONTH= 7  DAY= 6  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 769.0  DAILY DELAY (HOURS )=  13.5
ONTH= 7  DAY= 6  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 692.1  DAILY DELAY (HOURS )= 297.7
ONTH= 7  DAY= 6  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 692.1  DAILY DELAY (HOURS )=  76.7
ONTH= 7  DAY= 7  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 823.9  DAILY DELAY (HOURS )= 423.9
ONTH= 7  DAY= 7  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 823.9  DAILY DELAY (HOURS )=  90.4
ONTH= 7  DAY= 7  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 823.9  DAILY DELAY (HOURS )=  20.2
ONTH= 7  DAY= 7  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 741.5  DAILY DELAY (HOURS )= 345.2
ONTH= 7  DAY= 7  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 741.5  DAILY DELAY (HOURS )= 110.0
ONTH= 8  DAY= 1  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 814.9  DAILY DELAY (HOURS )= 403.4
ONTH= 8  DAY= 1  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 814.9  DAILY DELAY (HOURS )=  85.3
ONTH= 8  DAY= 1  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 814.9  DAILY DELAY (HOURS )=  19.2
ONTH= 8  DAY= 1  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 733.4  DAILY DELAY (HOURS )= 335.8
ONTH= 8  DAY= 1  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 733.4  DAILY DELAY (HOURS )= 104.7
ONTH= 8  DAY= 2  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 706.2  DAILY DELAY (HOURS )= 272.5
ONTH= 8  DAY= 2  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 706.2  DAILY DELAY (HOURS )=  41.9
ONTH= 8  DAY= 2  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 706.2  DAILY DELAY (HOURS )=   8.9
ONTH= 8  DAY= 2  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 635.6  DAILY DELAY (HOURS )= 179.3
ONTH= 8  DAY= 2  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 635.6  DAILY DELAY (HOURS )=  46.6
ONTH= 8  DAY= 3  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 760.6  DAILY DELAY (HOURS )= 335.9
ONTH= 8  DAY= 3  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 760.6  DAILY DELAY (HOURS )=  56.4
ONTH= 8  DAY= 3  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 760.6  DAILY DELAY (HOURS )=  12.7
ONTH= 8  DAY= 3  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 684.5  DAILY DELAY (HOURS )= 291.0
ONTH= 8  DAY= 3  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 684.5  DAILY DELAY (HOURS )=  72.5
ONTH= 8  DAY= 4  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 760.6  DAILY DELAY (HOURS )= 335.9
ONTH= 8  DAY= 4  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 760.6  DAILY DELAY (HOURS )=  56.4
ONTH= 8  DAY= 4  WEATHER= 1  RW CONF= 3  DAILY DEMAND= 760.6  DAILY DELAY (HOURS )=  12.7
ONTH= 8  DAY= 4  WEATHER= 2  RW CONF= 1  DAILY DEMAND= 684.5  DAILY DELAY (HOURS )= 291.0
ONTH= 8  DAY= 4  WEATHER= 2  RW CONF= 2  DAILY DEMAND= 684.5  DAILY DELAY (HOURS )=  72.5
ONTH= 8  DAY= 5  WEATHER= 1  RW CONF= 1  DAILY DEMAND= 814.9  DAILY DELAY (HOURS )= 403.4
ONTH= 8  DAY= 5  WEATHER= 1  RW CONF= 2  DAILY DEMAND= 814.9  DAILY DELAY (HOURS )=  85.3
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ONTH= 8	DAY= 5	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 814.9	DAILY DELAY (HOURS)= 19.2
ONTH= 8	DAY= 5	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 733.4	DAILY DELAY (HOURS)= 335.8
ONTH= 8	DAY= 5	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 733.4	DAILY DELAY (HOURS)= 104.7
ONTH= 8	DAY= 6	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 760.6	DAILY DELAY (HOURS)= 335.9
ONTH= 8	DAY= 6	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 760.6	DAILY DELAY (HOURS)= 56.4
ONTH= 8	DAY= 6	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 760.6	DAILY DELAY (HOURS)= 12.7
ONTH= 8	DAY= 6	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 684.5	DAILY DELAY (HOURS)= 291.0
ONTH= 8	DAY= 6	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 684.5	DAILY DELAY (HOURS)= 72.5
ONTH= 8	DAY= 7	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 814.9	DAILY DELAY (HOURS)= 403.4
ONTH= 8	DAY= 7	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 814.9	DAILY DELAY (HOURS)= 85.3
ONTH= 8	DAY= 7	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 814.9	DAILY DELAY (HOURS)= 19.2
ONTH= 8	DAY= 7	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 733.4	DAILY DELAY (HOURS)= 335.8
ONTH= 8	DAY= 7	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 733.4	DAILY DELAY (HOURS)= 104.7
ONTH= 9	DAY= 1	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 859.9	DAILY DELAY (HOURS)= 484.0
ONTH= 9	DAY= 1	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 859.9	DAILY DELAY (HOURS)= 115.0
ONTH= 9	DAY= 1	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 859.9	DAILY DELAY (HOURS)= 24.8
ONTH= 9	DAY= 1	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 773.9	DAILY DELAY (HOURS)= 385.8
ONTH= 9	DAY= 1	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 773.9	DAILY DELAY (HOURS)= 150.1
ONTH= 9	DAY= 2	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 745.3	DAILY DELAY (HOURS)= 326.9
ONTH= 9	DAY= 2	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 745.3	DAILY DELAY (HOURS)= 49.2
ONTH= 9	DAY= 2	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 745.3	DAILY DELAY (HOURS)= 11.5
ONTH= 9	DAY= 2	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 670.7	DAILY DELAY (HOURS)= 268.7
ONTH= 9	DAY= 2	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 670.7	DAILY DELAY (HOURS)= 64.9
ONTH= 9	DAY= 3	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 802.6	DAILY DELAY (HOURS)= 386.6
ONTH= 9	DAY= 3	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 802.6	DAILY DELAY (HOURS)= 78.4
ONTH= 9	DAY= 3	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 802.6	DAILY DELAY (HOURS)= 17.9
ONTH= 9	DAY= 3	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 722.3	DAILY DELAY (HOURS)= 324.5
ONTH= 9	DAY= 3	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 722.3	DAILY DELAY (HOURS)= 97.5
ONTH= 9	DAY= 4	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 802.6	DAILY DELAY (HOURS)= 386.6
ONTH= 9	DAY= 4	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 802.6	DAILY DELAY (HOURS)= 78.4
ONTH= 9	DAY= 4	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 802.6	DAILY DELAY (HOURS)= 17.9
ONTH= 9	DAY= 4	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 722.3	DAILY DELAY (HOURS)= 324.5
ONTH= 9	DAY= 4	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 722.3	DAILY DELAY (HOURS)= 97.5
ONTH= 9	DAY= 5	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 859.9	DAILY DELAY (HOURS)= 484.0
ONTH= 9	DAY= 5	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 859.9	DAILY DELAY (HOURS)= 115.0
ONTH= 9	DAY= 5	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 859.9	DAILY DELAY (HOURS)= 24.8
ONTH= 9	DAY= 5	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 773.9	DAILY DELAY (HOURS)= 385.8
ONTH= 9	DAY= 5	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 773.9	DAILY DELAY (HOURS)= 150.1
ONTH= 9	DAY= 6	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 802.6	DAILY DELAY (HOURS)= 386.6
ONTH= 9	DAY= 6	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 802.6	DAILY DELAY (HOURS)= 78.4
ONTH= 9	DAY= 6	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 802.6	DAILY DELAY (HOURS)= 17.9
ONTH= 9	DAY= 6	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 722.3	DAILY DELAY (HOURS)= 324.5
ONTH= 9	DAY= 6	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 722.3	DAILY DELAY (HOURS)= 97.5
ONTH= 9	DAY= 7	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 859.9	DAILY DELAY (HOURS)= 484.0
ONTH= 9	DAY= 7	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 859.9	DAILY DELAY (HOURS)= 115.0
ONTH= 9	DAY= 7	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 859.9	DAILY DELAY (HOURS)= 24.8
ONTH= 9	DAY= 7	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 773.9	DAILY DELAY (HOURS)= 385.8
ONTH= 9	DAY= 7	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 773.9	DAILY DELAY (HOURS)= 150.1
ONTH= 10	DAY= 1	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 882.4	DAILY DELAY (HOURS)= 527.6
ONTH= 10	DAY= 1	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 882.4	DAILY DELAY (HOURS)= 129.9
ONTH= 10	DAY= 1	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 882.4	DAILY DELAY (HOURS)= 35.2
ONTH= 10	DAY= 1	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 794.2	DAILY DELAY (HOURS)= 423.3
ONTH= 10	DAY= 1	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 794.2	DAILY DELAY (HOURS)= 170.1
ONTH= 10	DAY= 2	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 764.8	DAILY DELAY (HOURS)= 340.9
ONTH= 10	DAY= 2	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 764.8	DAILY DELAY (HOURS)= 58.5
ONTH= 10	DAY= 2	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 764.8	DAILY DELAY (HOURS)= 13.1
ONTH= 10	DAY= 2	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 688.3	DAILY DELAY (HOURS)= 294.3
ONTH= 10	DAY= 2	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 688.3	DAILY DELAY (HOURS)= 74.7
ONTH= 10	DAY= 3	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 823.6	DAILY DELAY (HOURS)= 423.5
ONTH= 10	DAY= 3	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 823.6	DAILY DELAY (HOURS)= 90.3
ONTH= 10	DAY= 3	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 823.6	DAILY DELAY (HOURS)= 20.2
ONTH= 10	DAY= 3	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 741.2	DAILY DELAY (HOURS)= 344.8
ONTH= 10	DAY= 3	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 741.2	DAILY DELAY (HOURS)= 109.9
ONTH= 10	DAY= 4	WEATHER= 1	RW CONF= 1	DAILY DEMAND= 823.6	DAILY DELAY (HOURS)= 423.5
ONTH= 10	DAY= 4	WEATHER= 1	RW CONF= 2	DAILY DEMAND= 823.6	DAILY DELAY (HOURS)= 90.3
ONTH= 10	DAY= 4	WEATHER= 1	RW CONF= 3	DAILY DEMAND= 823.6	DAILY DELAY (HOURS)= 20.2
ONTH= 10	DAY= 4	WEATHER= 2	RW CONF= 1	DAILY DEMAND= 741.2	DAILY DELAY (HOURS)= 344.8
ONTH= 10	DAY= 4	WEATHER= 2	RW CONF= 2	DAILY DEMAND= 741.2	DAILY DELAY (HOURS)= 109.9

ONTH=	10	DAY= 5	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	882.4	DAILY DELAY (HOURS)=	527.6
ONTH=	10	DAY= 5	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	882.4	DAILY DELAY (HOURS)=	129.9
ONTH=	10	DAY= 5	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	882.4	DAILY DELAY (HOURS)=	35.2
ONTH=	10	DAY= 5	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	794.2	DAILY DELAY (HOURS)=	423.3
ONTH=	10	DAY= 5	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	794.2	DAILY DELAY (HOURS)=	170.1
ONTH=	10	DAY= 6	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	823.6	DAILY DELAY (HOURS)=	423.5
ONTH=	10	DAY= 6	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	823.6	DAILY DELAY (HOURS)=	90.3
ONTH=	10	DAY= 6	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	823.6	DAILY DELAY (HOURS)=	20.2
ONTH=	10	DAY= 6	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	741.2	DAILY DELAY (HOURS)=	344.8
ONTH=	10	DAY= 6	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	741.2	DAILY DELAY (HOURS)=	109.9
ONTH=	10	DAY= 7	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	882.4	DAILY DELAY (HOURS)=	527.6
ONTH=	10	DAY= 7	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	882.4	DAILY DELAY (HOURS)=	129.9
ONTH=	10	DAY= 7	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	882.4	DAILY DELAY (HOURS)=	35.2
ONTH=	10	DAY= 7	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	794.2	DAILY DELAY (HOURS)=	423.3
ONTH=	10	DAY= 7	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	794.2	DAILY DELAY (HOURS)=	170.1
ONTH=	11	DAY= 1	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	922.9	DAILY DELAY (HOURS)=	648.6
ONTH=	11	DAY= 1	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	922.9	DAILY DELAY (HOURS)=	160.3
ONTH=	11	DAY= 1	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	922.9	DAILY DELAY (HOURS)=	53.7
ONTH=	11	DAY= 1	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	830.7	DAILY DELAY (HOURS)=	484.9
ONTH=	11	DAY= 1	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	830.7	DAILY DELAY (HOURS)=	211.6
ONTH=	11	DAY= 2	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	799.9	DAILY DELAY (HOURS)=	383.1
ONTH=	11	DAY= 2	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	799.9	DAILY DELAY (HOURS)=	77.0
ONTH=	11	DAY= 2	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	799.9	DAILY DELAY (HOURS)=	17.7
ONTH=	11	DAY= 2	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	719.9	DAILY DELAY (HOURS)=	322.1
ONTH=	11	DAY= 2	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	719.9	DAILY DELAY (HOURS)=	96.0
ONTH=	11	DAY= 3	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	861.4	DAILY DELAY (HOURS)=	486.3
ONTH=	11	DAY= 3	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	861.4	DAILY DELAY (HOURS)=	115.9
ONTH=	11	DAY= 3	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	861.4	DAILY DELAY (HOURS)=	25.0
ONTH=	11	DAY= 3	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	775.3	DAILY DELAY (HOURS)=	387.6
ONTH=	11	DAY= 3	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	775.3	DAILY DELAY (HOURS)=	151.4
ONTH=	11	DAY= 4	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	861.4	DAILY DELAY (HOURS)=	486.3
ONTH=	11	DAY= 4	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	861.4	DAILY DELAY (HOURS)=	115.9
ONTH=	11	DAY= 4	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	861.4	DAILY DELAY (HOURS)=	25.0
ONTH=	11	DAY= 4	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	775.3	DAILY DELAY (HOURS)=	387.6
ONTH=	11	DAY= 4	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	775.3	DAILY DELAY (HOURS)=	151.4
ONTH=	11	DAY= 5	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	922.9	DAILY DELAY (HOURS)=	648.6
ONTH=	11	DAY= 5	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	922.9	DAILY DELAY (HOURS)=	160.3
ONTH=	11	DAY= 5	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	922.9	DAILY DELAY (HOURS)=	53.7
ONTH=	11	DAY= 5	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	830.7	DAILY DELAY (HOURS)=	484.9
ONTH=	11	DAY= 5	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	830.7	DAILY DELAY (HOURS)=	211.6
ONTH=	11	DAY= 6	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	861.4	DAILY DELAY (HOURS)=	486.3
ONTH=	11	DAY= 6	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	861.4	DAILY DELAY (HOURS)=	115.9
ONTH=	11	DAY= 6	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	861.4	DAILY DELAY (HOURS)=	25.0
ONTH=	11	DAY= 6	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	775.3	DAILY DELAY (HOURS)=	387.6
ONTH=	11	DAY= 6	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	775.3	DAILY DELAY (HOURS)=	151.4
ONTH=	11	DAY= 7	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	922.9	DAILY DELAY (HOURS)=	648.6
ONTH=	11	DAY= 7	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	922.9	DAILY DELAY (HOURS)=	160.3
ONTH=	11	DAY= 7	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	922.9	DAILY DELAY (HOURS)=	53.7
ONTH=	11	DAY= 7	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	830.7	DAILY DELAY (HOURS)=	484.9
ONTH=	11	DAY= 7	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	830.7	DAILY DELAY (HOURS)=	211.6
ONTH=	12	DAY= 1	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	904.9	DAILY DELAY (HOURS)=	605.0
ONTH=	12	DAY= 1	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	904.9	DAILY DELAY (HOURS)=	145.5
ONTH=	12	DAY= 1	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	904.9	DAILY DELAY (HOURS)=	46.2
ONTH=	12	DAY= 1	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	814.4	DAILY DELAY (HOURS)=	460.9
ONTH=	12	DAY= 1	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	814.4	DAILY DELAY (HOURS)=	194.1
ONTH=	12	DAY= 2	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	784.3	DAILY DELAY (HOURS)=	364.6
ONTH=	12	DAY= 2	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	784.3	DAILY DELAY (HOURS)=	68.6
ONTH=	12	DAY= 2	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	784.3	DAILY DELAY (HOURS)=	16.2
ONTH=	12	DAY= 2	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	705.9	DAILY DELAY (HOURS)=	309.6
ONTH=	12	DAY= 2	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	705.9	DAILY DELAY (HOURS)=	84.5
ONTH=	12	DAY= 3	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	844.6	DAILY DELAY (HOURS)=	460.6
ONTH=	12	DAY= 3	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	844.6	DAILY DELAY (HOURS)=	102.3
ONTH=	12	DAY= 3	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	844.6	DAILY DELAY (HOURS)=	22.7
ONTH=	12	DAY= 3	WEATHER= 2	RW	CONF= 1	DAILY DEMAND=	760.1	DAILY DELAY (HOURS)=	368.1
ONTH=	12	DAY= 3	WEATHER= 2	RW	CONF= 2	DAILY DEMAND=	760.1	DAILY DELAY (HOURS)=	122.8
ONTH=	12	DAY= 4	WEATHER= 1	RW	CONF= 1	DAILY DEMAND=	844.6	DAILY DELAY (HOURS)=	460.6
ONTH=	12	DAY= 4	WEATHER= 1	RW	CONF= 2	DAILY DEMAND=	844.6	DAILY DELAY (HOURS)=	102.3
ONTH=	12	DAY= 4	WEATHER= 1	RW	CONF= 3	DAILY DEMAND=	844.6	DAILY DELAY (HOURS)=	22.7

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ONTH= 12   DAY= 4   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 760.1   DAILY DELAY (HOURS )=  368.1
ONTH= 12   DAY= 4   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 760.1   DAILY DELAY (HOURS )=  122.8
ONTH= 12   DAY= 5   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 904.9   DAILY DELAY (HOURS )=  605.0
ONTH= 12   DAY= 5   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 904.9   DAILY DELAY (HOURS )=  145.5
ONTH= 12   DAY= 5   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 904.9   DAILY DELAY (HOURS )=   46.2
ONTH= 12   DAY= 5   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 814.4   DAILY DELAY (HOURS )=  460.9
ONTH= 12   DAY= 5   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 814.4   DAILY DELAY (HOURS )=  194.1
ONTH= 12   DAY= 6   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 844.6   DAILY DELAY (HOURS )=  460.6
ONTH= 12   DAY= 6   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 844.6   DAILY DELAY (HOURS )=  102.3
ONTH= 12   DAY= 6   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 844.6   DAILY DELAY (HOURS )=   22.7
ONTH= 12   DAY= 6   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 760.1   DAILY DELAY (HOURS )=  368.1
ONTH= 12   DAY= 6   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 760.1   DAILY DELAY (HOURS )=  122.8
ONTH= 12   DAY= 7   WEATHER= 1   RW CONF= 1   DAILY DEMAND= 904.9   DAILY DELAY (HOURS )=  605.0
ONTH= 12   DAY= 7   WEATHER= 1   RW CONF= 2   DAILY DEMAND= 904.9   DAILY DELAY (HOURS )=  145.5
ONTH= 12   DAY= 7   WEATHER= 1   RW CONF= 3   DAILY DEMAND= 904.9   DAILY DELAY (HOURS )=   46.2
ONTH= 12   DAY= 7   WEATHER= 2   RW CONF= 1   DAILY DEMAND= 814.4   DAILY DELAY (HOURS )=  460.9
ONTH= 12   DAY= 7   WEATHER= 2   RW CONF= 2   DAILY DEMAND= 814.4   DAILY DELAY (HOURS )=  194.1

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ANNUAL SUMMARY

AVERAGE DELAY (MINUTES) AT LEAST	LESS THAN	DISTRIBUTION PERCENT OCCURRENCE	
0.0	0.2	9.001	9.0
0.2	0.4	13.318	22.3
0.4	0.6	11.583	33.9
0.6	0.8	7.700	41.6
0.8	1.0	4.420	46.0
1.0	1.2	2.409	48.4
1.2	1.4	2.448	50.9
1.4	1.6	1.225	52.1
1.6	1.8	1.032	53.1
1.8	2.0	1.371	54.5
2.0	3.0	5.490	60.0
3.0	4.0	9.661	69.7
4.0	5.0	2.908	72.6
5.0	6.0	2.056	74.6
6.0	7.0	1.267	75.9
7.0	8.0	3.034	78.9
8.0	9.0	2.329	81.3
9.0	10.0	0.816	82.1
10.0	11.0	0.683	82.8
11.0	12.0	1.682	84.4
12.0	13.0	1.003	85.4
13.0	14.0	1.535	87.0
14.0	15.0	1.112	88.1
15.0	16.0	1.402	89.5
16.0	17.0	0.520	90.0
17.0	18.0	1.157	91.2
18.0	19.0	0.024	91.2
19.0	20.0	0.830	92.0
20.0	21.0	1.142	93.2
24.0	25.0	0.168	93.3
25.0	26.0	0.747	94.1
26.0	27.0	0.154	94.2
27.0	28.0	0.169	94.4
31.0	32.0	0.016	94.4
32.0	33.0	0.002	94.4
34.0	35.0	0.005	94.4
35.0	36.0	0.003	94.4
36.0	37.0	0.045	94.5
38.0	39.0	0.003	94.5
41.0	42.0	0.093	94.6
42.0	43.0	0.001	94.6
43.0	44.0	0.057	94.6
45.0	46.0	0.071	94.7
46.0	47.0	0.582	95.3
47.0	48.0	0.294	95.6
48.0	49.0	0.252	95.8
49.0	50.0	0.182	96.0
50.0	51.0	0.412	96.4
51.0	52.0	0.377	96.8
52.0	53.0	0.574	97.4
53.0	54.0	0.396	97.8
54.0	55.0	0.264	98.0
55.0	56.0	0.405	98.4
56.0	57.0	0.442	98.9
58.0	59.0	0.446	99.3
59.0	60.0	0.241	99.6
95.0	96.0	0.441	100.0

MEAN OF AVERAGE DELAY = 6.55
STANDARD DEVIATION = 8.07

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ANNUAL DELAY =   32764.0  HOURS
ANNUAL DEMAND =   300000  OPERATIONS
AVERAGE DELAY =     6.55  MINUTES-AIRCRAFT
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MONTHLY SUMMARY OF ANNUAL DELAY

MONTH	ANNUAL DELAY HOURS
1	2847.2
2	5228.0
3	2265.4
4	2362.5
5	2053.1
6	1818.0
7	2161.0
8	2027.8
9	2461.2
10	2847.2
11	3443.7
12	3249.5

SUMMARY OF ANNUAL DELAY BY DAY OF WEEK

DAY	ANNUAL DELAY HOURS
1	5862.1
2	2998.5
3	4059.9
4	4059.9
5	5862.1
6	4059.9
7	5862.1

SUMMARY OF ANNUAL DELAY BY WEATHER CONDITION

WEATHER	ANNUAL DELAY HOURS
1	32158.9
2	605.3

SUMMARY OF ANNUAL DELAY BY WEATHER AND RW CONF

WEATHER	RW CONF	ANNUAL DELAY HOURS
1	1	16659.4
1	2	10329.7
1	3	5169.9
2	1	353.4
2	2	252.0
2	3	0.0

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RUNID      16
EXAMPLE 1
ANNDEMAND   1
  400000
DEMPROFILE12
   35
GROUPS      2
     7    12     2     3
WKPERCENT   3
0.01960.02180.01850.01890.01810.01770.01830.01810.01910.01960.02050.0201
WKNUMBER    4
4.43004.00004.43004.29004.43004.29004.43004.43004.29004.43004.29004.4300
DPERCENT    5
0.15000.13000.14000.14000.15000.14000.1500
DAYNUMBER   6
     1     1     1     1     1     1     1
HOURPCT    11
0.00600.00500.00200.00200.00100.00100.00300.02500.08600.07100.03300.0600
0.04300.05200.03800.04200.07800.12200.09800.10700.06900.02900.01700.0100
WEAPCT      8
1.00000.99000.98000.99000.98000.98000.98000.99000.99001.00001.00001.0000
0.0    0.01000.02000.01000.02000.02000.02000.01000.01000.0    0.0    0.0
DEMANPCT    7
1.00000.9000
RWYUSEPCT 10
0.10000.3000
0.30000.7000
0.60000.0
RWYDEMPCT 13
1.00001.00001.0000
CAPACITY    9
 52.0 50.0
 72.0 60.0
 95.0  0.0
MIX INDEX 14
  140  160
  140  160
  140  160
FIG NUMS  15
 2- 3 2-43 2-
 2- 4 2-44 2-
 2- 9 2- 0 2-
```

```
********************************
*   AIRPORT STUDY CONDITIONS   *
*     EXAMPLE 1                      *
********************************
```

ATCH ANNUAL DELAY MODEL VERSION 1, FEB 1977

****

ANNUAL SUMMARY

AVERAGE DELAY (MINUTES) AT LEAST	LESS THAN	DISTRIBUTION PERCENT OCCURRENCE	
0.0	0.2	4.207	4.2
0.2	0.4	7.905	12.1
0.4	0.6	4.616	16.7
0.6	0.8	3.990	20.6
0.8	1.0	2.933	23.6
1.0	1.2	1.902	25.5
1.2	1.4	0.932	26.4
1.4	1.6	1.392	27.8
1.6	1.8	1.199	29.0
1.8	2.0	0.559	29.5
2.0	3.0	4.668	34.2
3.0	4.0	4.184	38.4
4.0	5.0	2.638	41.0
5.0	6.0	1.356	42.4
6.0	7.0	0.692	43.1
7.0	8.0	1.228	44.3
8.0	9.0	0.671	45.0
9.0	10.0	2.463	47.4
10.0	11.0	3.349	50.8
11.0	12.0	0.547	51.3
12.0	13.0	0.809	52.1
13.0	14.0	0.280	52.4
14.0	15.0	2.036	54.5
15.0	16.0	1.489	55.9
16.0	17.0	0.466	56.4
18.0	19.0	1.789	58.2
19.0	20.0	2.763	61.0
20.0	21.0	1.036	62.0
21.0	22.0	0.541	62.5
22.0	23.0	1.427	64.0
23.0	24.0	1.435	65.4
25.0	26.0	2.177	67.6
26.0	27.0	0.604	68.2
27.0	28.0	0.033	68.2
28.0	29.0	3.193	71.4
29.0	30.0	0.834	72.2
30.0	31.0	0.686	72.9
31.0	32.0	1.842	74.8
32.0	33.0	3.255	78.0
33.0	34.0	0.567	78.6
34.0	35.0	1.116	79.7
35.0	36.0	0.076	79.8
36.0	37.0	1.745	81.5
37.0	38.0	0.601	82.1
39.0	40.0	0.617	82.7
40.0	41.0	0.783	83.5
42.0	43.0	0.007	83.5
44.0	45.0	1.468	85.0
49.0	50.0	1.261	86.3
50.0	51.0	0.036	86.3
51.0	52.0	1.376	87.7
52.0	53.0	0.714	88.4
53.0	54.0	1.355	89.7
55.0	56.0	0.002	89.7
56.0	57.0	0.751	90.5
57.0	58.0	0.005	90.5
59.0	60.0	0.054	90.6
60.0	61.0	0.093	90.6
61.0	62.0	0.070	90.7
62.0	63.0	0.058	90.8
83.0	84.0	0.028	90.8
91.0	92.0	0.009	90.8
93.0	94.0	0.611	91.4
94.0	95.0	0.496	91.9
95.0	96.0	0.108	92.0
96.0	97.0	0.580	92.6
97.0	98.0	0.127	92.7
98.0	99.0	0.105	92.8
MORE THAN	100.0	7.161	

MEAN OF AVERAGE DELAY = 22.98
STANDARD DEVIATION = 14.25

****

ANNUAL DELAY = 153227.0 HOURS
ANNUAL DEMAND = 400000 OPERATIONS
AVERAGE DELAY = 22.98 MINUTES-AIRCRAFT

MONTHLY SUMMARY OF ANNJAL DELAY

MONTH	ANNUAL DELAY HOURS
1	14088.9
2	19665.5
3	10680.7
4	11594.5
5	9759.4
6	8713.6
7	10195.7
8	9679.5
9	12467.3
10	14088.9
11	16675.8
12	15622.9

SUMMARY OF ANNUAL DELAY BY DAY OF WEEK

DAY	ANNUAL DELAY HOURS
1	26811.1
2	13474.4
3	19774.9
4	19774.9
5	26811.1
6	19774.9
7	26811.1

SUMMARY OF ANNUAL DELAY BY WEATHER CONDITION

WEATHER	ANNUAL DELAY HOURS
1	150793.2
2	2435.3

SUMMARY OF ANNUAL DELAY BY WEATHER AND RW CONF

WEATHER	RW CONF	ANNUAL DELAY HOURS
1	1	65702.1
1	2	45432.7
1	3	39662.5
2	1	1286.5
2	2	1148.8
2	3	0.0

CHAPTER 6 - ON-LINE ANNUAL DELAY MODEL VERSION 1 - ANNUAL DELAY

6.1 Introduction

The On-line Annual Delay Model Version 1 is an adaptation of the general Annual Delay Model described in Chapter 5. It is similar in operation to the On-line Runway Capacity Model discussed in Chapter 3.

The On-line Annual Delay Model provides a structured way to determine the total delay to runway operations for a year. The On-line Annual Delay Model considers the distribution of hourly demand over a 24-hour day, the daily distribution of demand over a 7-day week, the monthly distribution of demand over a year, and the monthly distribution of three weather categories over a year. The On-line Annual Delay Model can be run with user supplied data or a combination of user supplied and built-in data.

A list of computer services (or timesharing companies) offering the program can be obtained from:

Chief, Airport Design Branch, ARD-410
DOT/FAA
2100 Second Street, S.W.
Washington, D.C. 20590

(202) 426-3685

6.2 Discussion of Terms Used by On-line Annual Delay Model

a. Monthly Distribution of Annual Operations. The monthly distribution of annual operations is defined as the percent of annual operations that occur in each month.

The On-line Annual Delay Model has seven built-in distributions of annual operations. These are identified by annual operations distribution letters:

- a Uniform distribution; i.e., the same percentage each month.
- b Based on large air carrier airports with small monthly variations of demand.
- c Based on large air carrier airports with moderate monthly variations of demand.
- d Based on large air carrier airports with substantial monthly variations of demand.

e Based on large general aviation airports with small monthly variations of demand.

f Based on large general aviation airports with moderate monthly variations of demand.

g Based on medium size general aviation airports with substantial monthly variations of demand.

When possible, it is desirable to use site specific annual operation distributions. A monthly summary of total operations by airport can be obtained by contacting:

Information Operations Branch, AMS-220
DOT/FAA
800 Independence Ave., S.W.
Washington, D.C. 20590

(202) 426-3791

More detail data containing the daily tower count can be obtained by contacting:

Aviation Forecast Branch, AVP-120
DOT/FAA
800 Independence Ave., S.W.
Washington, D.C. 20590

(202) 426-3103

The sequence in which monthly percents are entered is not important. However, the distribution of annual operations must be coordinated with the annual weather distribution.

b. Monthly Distribution of Weather. The monthly distribution of weather is defined as the percent of the time that VFR, IFR and PVC operating conditions occur each month.

The On-line Annual Delay Model has four built-in distributions of weather. These are identified by annual weather distribution letters.

a 99% VFR, 1% IFR, 0% PVC
b 95% VFR, 4% IFR, 1% PVC
c 88% VFR, 11% IFR, 1% PVC
d 80% VFR, 18% IFR, 2% PVC

When possible, it is desirable to use site specific weather distributions. Monthly weather data can be obtained from the National Weather Records Center in Ashville, North Carolina.

The input weather percentages represent the percent of the days where that weather condition exists all day. Therefore, the

percent of the days which are VFR, IFR, and PVC should not include weather conditions which only occur during very low demand periods of the day; e.g., do not include in this proportion days during which the bad weather only occurs between 10:00 p.m. and 5:00 a.m.

c. Daily Demand Distribution. The daily demand distribution is defined as the percent of the weekly demand that occurs in each day.

The On-line Annual Delay Model has six built-in distributions of daily demand. These are identified by daily demand distribution letters.

- a Same demand per day
- b Peak day = 1.15 x (minimum day)
- c Peak day = 1.25 x (minimum day)
- d Peak day = 1.50 x (minimum day)
- e Peak day = 1.70 x (minimum day)
- f Two days each with 25% of the weeks demand, the other five days each have 10%

When possible, it is desirable to use site specific daily demand distributions. Data on the daily distribution of demand is contained in "Tower Airport Statistics Handbook" published annually by:

Chief, Aviation Forecast Branch, AVP-120
DOT/FAA
800 Independence Ave., S.W.
Washington, D.C. 20590

(202) 426-3103

The sequence in which the daily demand distribution percentages are entered has no impact on annual delay. The important data is the magnitude of the seven numbers. The Annual Delay Model assumes that every week of each month has the same daily demand distribution.

d. Hourly Demand Distribution. The hourly demand distribution is defined as the percent of the daily demand that occurs in each hour.

The On-line Annual Delay Model has nine built-in distributions of hourly demand. These are identified by hourly demand distribution letters.

- a Uniform over 16 hours
- b Based on the three largest air carrier airports
- c Based on the rest of the 10 largest air carrier airports
- d Based on other airports in the 20 largest air carrier airports

e Based on selected medium hub air carrier airports
f Based on selected large general aviation airports
g Based on selected small hub air carrier airports
h Based on selected medium sized general aviation airports
i Based on selected small general aviation airports

When possible, it is desirable to use site specific hourly demand distributions. Data on the hourly distribution of demand can usually be obtained by contacting the tower chief at the respective airport.

e. Hourly Distribution of Demand by Weather Condition. The On-line Annual Delay Model considers three weather conditions; i.e., VFR, IFR and PVC. These weather conditions have the same meanings as used in Chapter 3.

The On-line Annual Delay Model will allow the level of operations in IFR and PVC to be set equal to some percent of the level of operations in VFR. This accounts for the general phenomena that demand in IFR is lower than in VFR because uninstrumented aircraft are prevented from using the runways, and demand in PVC is much lower than VFR because of poor operating conditions.

f. Runway Use Configuration Utilization Percent by Weather. The On-line Annual Delay Model requires the percent of the time that each runway use configuration is used. This is done for all VFR, all IFR and all PVC runway use configurations. The model assumes that the capacity of each runway use configuration is constant across the day. Therefore, it is advisable not to enter data for runway use configurations that are only used during very low demand time periods (e.g., 10:00 p.m. to 5:00 a.m.).

It is recommended that only runway use configurations that occur for at least 2% of the VFR, or IFR or PVC days be considered in the annual delay analysis.

g. Demand Profile Factor. The demand profile factor is defined as the percent of the hourly demand that occurs in the peak 15 minutes. To allow for the variation of demand profile factor from hour to hour, input the average demand profile factor for the busy hours of the day.

h. Touch-and-Go Operations. Touch-and-go operations do not normally occur during busy hours at commercial airports. Therefore, touch-and-go operations should be excluded from the annual operations when determining annual delay for commercial airports. If touch-and-go operations are included in the annual operations for a general aviation airport, the hourly

capacities should be based on the same percent touch-and-go. The Annual Delay Model treats touch-ang-qo operations as one arrival and one departure. If a runway use configuration consists of one runway used exclusively for touch-and-go operations and one runway for arrival and departure operations, the annual delay analysis should be done separately for each runway.

6.3 Data Requests

The following defines the data requests and acceptable inputs for the On-line Annual Delay Model:

ENTER ANNUAL DEMAND

This data request is typed after the program identification code is entered (e.g., EX AND). Enter the total number of arrivals plus departures for the year. A comma is not used for values over 1000 (e.g., enter 225000 instead of 225,000).

ENTER FOR EVERY MONTH
PERCENT OF ANNUAL DEMAND
PERCENT OF MONTH WHICH IS VFR, IFR, AND PVC
JANUARY

Four numbers should be entered on the line immediately after the word January (e.g., 7.6 96 3 1). A space should separate each number. The first number is January's percent of annual operations and the second, third, and fourth numbers are the percent of January days which are VFR, IFR, and PVC respectively. The second, third, and fourth numbers must sum to 100. The terminal will request data for FEBRUARY as soon as valid input data is provided for January. This process is repeated until the data have been entered for all 12 months. The terminal will repeat the entire data request if the monthly percentages of annual operations do not sum to 100.

As an alternative to entering the annual operations and weather distributions, the user can enter an annual operations distribution letter and annual weather distribution letter for the JANUARY input. The On-line Annual Delay Model will then proceed to the next question.

ENTER IFR AND PVC OPERATIONS AS A PERCENT OF VFR OPERATIONS

This data request requires two numbers (each between 0 and 100) be entered with a space between them. The first number is: 100 times the operations on an average IFR day divided by operations on an average VFR day. The second number is: 100 times the operations on an average PVC day divided by operations on an average VFR day.

ENTER DAILY OPERATIONS AS A PERCENT OF WEEKLY OPERATIONS MONDAY

This data request requires one number (between 0 and 100) be entered. The terminal will type TUESDAY after a number is entered for Monday; another number should be entered on this line. This process is repeated until a number has been entered for each day of the week. This entire data request is repeated if the seven numbers do not sum to 100.

As an alternative to entering the daily demand distribution, the user can enter the daily demend distribution letter for the MONDAY input. The On-line Annual Delay Model will then proceed to the next question.

ENTER HOURLY OPERATIONS AS A PERCENT OF DAILY OPERATIONS
0-1

This data request requires one number (between 0 and 100) be entered. The terminal will automatically type "1-2" as soon as data has been entered for the hour "0-1." This process is repeated through the hour "23-24." The terminal will repeat the entire data request if the 24 numbers do not sum to 100.

As an alternative to entering the hourly demand distribution, the user can enter the hourly demand distribution letter for the 0-1 input. The On-line Annual Delay Model will then proceed to the next question.

ENTER DEMAND PROFILE FACTOR

This data request requires one number. Acceptable values of the demand profile factor are 25, 30, 35, 40, 45 and 50.

ENTER THE FOLLOWING FOR EVERY VFR RUNWAY USAGE: RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX, HOURLY RUNWAY CAPACITY, AND PERCENT OF THE VFR DAYS USED

This data request requires one or more lines of data where each line of data is for a specific VFR runway use configuration. The first number per line is an integer 1 through 122 which defines the runway use configuration as illustrated in Figure 6-1. (Figure 2-2 in the computer question refers to Figure 2-2 in reference b.) The second number is the mix index; i.e., % C aircraft + 3 % D aircraft. The third number is the hourly runway capacity as computed from Chapter 2 or 3. The fourth number per line is the percent of the VFR days that the runway use configuration is used. The percent of the VFR days used summed over all VFR runway use configurations must sum to 100.

Any number of lines of data can be entered. Every line of data has four numbers. The first number is an integer 1 through

122, the second number is an integer 0 through 300, the third number is a positive number less than 500, and the fourth number is between 1 and 100.

> ENTER THE FOLLOWING FOR EVERY IFR RUNWAY USAGE: RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX, HOURLY RUNWAY CAPACITY, AND PERCENT OF THE IFR DAYS USED

This data request is the IFR version of the preceeding data request. The input format is identical to that for VFR runway usages. The computer will go to the next data request when the "percent of the IFR days used" sums to 100.

> ENTER THE FOLLOWING FOR EVERY PVC RUNWAY USAGE: RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX, HOURLY RUNWAY CAPACITY, AND PERCENT OF THE PVC DAYS USED

This data request is the PVC version of the previous two data requests. It is necessary to enter data for this data request even if PVC weather does not occur (e.g., enter 1 1 1 100).

6.4 Output

Immediately after the PVC runway use configuration data is entered, the On-line Annual Delay Model will type an input summary. The input summary defines the data used to determine annual delay; this includes the actual data if built-in data is used for: monthly percent of annual operations and monthly weather distribution, daily percent of the weekly operations, the hourly percent of the daily operations. The input summary does not contain any error messages and can serve as a permanent record of inputs used for the calculation.

The output of the On-line Annual Delay Model is typed after the input summary. The output includes:

a. the total annual runway delay (in hours and minutes)

b. the average runway delay per operation (in minutes)

c. the distribution of delay per operation

The distribution of delay per operation (item c.) has been deleted from the On-line Annual Delay Model to reduce output printing time.

After the output is printed, it is possible to do parametric variations on annual opeations. The teletype will print: DO YOU WISH TO DETERMINE ANNUAL DELAY FOR ANOTHER ANNUAL DEMAND? If a "y" response is given, the terminal will make the data request ENTER ANNUAL DEMAND and calculate annual delay assuming all other inputs are identical. If any response other than "y" is given, the terminal will type the following data request:

DO YOU WISH TO PERFORM ANOTHER CALCULATION?

A "y" response to this data request will repeat the entire series of data requests for the On-line Annual Delay Model. Any other response will automatically terminate use of the On-line Annual Delay Model.

6.5 Optional uses of On-line Annual Delay Model

The On-line Annual Delay Model can be used with built-in demand distribution data to calculate:

The delay for an hour
The delay for a series of hours
The delay for a day
The delay for a week
The delay for a month
Measures of annual capacity

The following defines procedures for determining these outputs:

a. Hourly Delay. The hourly delay for a given demand per hour can be determined by:

1) Entering annual operations equal to the hourly demand x 5840. (NOTE: The On-line Annual Delay Model requires an annual demand equal to 5840 times hourly demand and the use of hourly demand distribution letter a in order to compute average delay per operation for the desired hourly demand.)

2) Entering a for the JANUARY annual demand distribution data.

3) Entering 100 100 for IFR and PVC operations as a percent of VFR.

4) Entering a for the MONDAY daily demand distribution data.

5) Entering a for the 0-1 hourly demand distribution data.

6) Entering 100 for the percent of VFR days used in the runway use configuration capacity data. Enter the appropriate runway use diagram number, mix index and hourly runway capacity.

7) Entering the same capacity and percent utilization data for IFR and PVC conditions as was used for VFR conditions.

The model output of average delay per operation is the average delay per operation for the hour under consideration.

b. Delay for a Series of Consecutive Hours. The delay for 2 or more consecutive hours up to 24 hours can be determined by:

1) Entering annual operations equal to the total hourly demand for the series of hours x 365.

2) Entering a for the January annual demand distribution data.

3) Entering 100 100 for IFR and PVC operations as a percent of VFR.

4) Entering a for the Monday daily demand distribution data.

5) Entering the hourly demand percents based on the total demand for the series of hours under consideration. Enter zero for all other hours. The entered values must sum to 100.0.

6) Entering 100 for the percent of VFR days used in the runway use configuration capacity data. Enter the appropriate runway use diagram number, mix index and hourly runway capacity.

7) Entering the same capacity and percent utilization data for IFR and PVC conditions as was used for VFR conditions.

The model output of average delay per operation is the average delay per operation over the time span considered.

c. Daily Delay. The average delay per operation for a day can be determined by following the procedure defined by b. above using an hourly demand distribution for the complete 24-hour period.

d. Weekly Delay. The average delay per operation for a particular week can be determined by computing the daily delay for the conditions specific to each day (or group of days) of the week.

e. Monthly Delay. The average delay per operation for a particular month can be determined by computing the daily delay for the conditions specific to each day (or group of days) of the month.

f. Measures of Annual Capacity. The On-line Annual Delay Model can be used to determine a level of service of annual capacity based on:

1) The average delay per operation produced by a given number of annual operations.

2) The percent of annual operations having delays in excess of some selected delay per operation.

3) Some combination of the above.

The procedure is to operate the model at different values of annual operations but keeping all other inputs fixed. This can easily be done by entering "y" to the question: DO YOU WISH TO DETERMINE ANNUAL DELAY FOR ANOTHER ANNUAL DEMAND? The model output can then be analyzed to determine annual capacity based on user specified level of service considerations.

6.6 Examples

The following examples illustrate the use of On-line Annual Delay Model Version 1. Common data for all examples are:

Percent Arrival = 50
Percent Touch-and-Go = 0
Mix index = 120; i.e., 0%A, 10%B, 60%C, 30%D
Demand Profile Factor = 40

Geometry	Diagram Number	Capacity VFR	Capacity IFR	Percent Utilization VFR	Percent Utilization IFR
Single Runway	1	54	52	10	30
Parallel Runway	2	77	60	50	45
Intersecting Runway	43	75	59	40	25

Example 1

Compute the total annual delay and average annual delay per operation for the following conditions:

Annual demand = 200,000 and 300,000 operations/year
Annual demand distribution b
Annual weather distribution a
Daily demand distribution d
Hourly demand distribution b
IFR demand = 90% of VFR demand

The computer dialogue for this problem is shown in Figure 6-1. The annual delay is:

Annual Demand	Annual Delay
200000	1396 hours
300000	9697 hours

NOTE: The *** in the Input Summary for VFR weather means that VFR weather conditions occur 100 percent of the month.

Example 2

Analyze annual delay for the following conditions:

Annual demand = 250,000 operations
IFR demand = 100% of VFR demand

Annual Demand Distribution

January	9.1	July	7.7
February	9.4	August	7.4
March	9.4	September	7.4
April	9.4	October	8.0
May	8.0	November	8.1
June	7.4	December	8.7

Annual Weather Distribution

	VFR	IFR	PVC		VFR	IFR	PVC
January	91	9	0	July	84	16	0
February	90	10	0	August	87	13	0
March	91	9	0	September	86	14	0
April	87	13	0	October	86	14	0
May	90	10	0	November	87	13	0
June	89	11	0	December	89	11	0

Daily Demand Distribution

Monday	14	Friday	15
Tuesday	16	Saturday	13
Wednesday	14	Sunday	13
Thursday	15		

Hourly Demand Distribution

0-1	2.27	6-7	1.53	12-13	5.28	18-19	6.51
1-2	1.81	7-8	4.11	13-14	5.56	19-20	6.69
2-3	1.19	8-9	6.47	14-15	5.16	20-21	5.94
3-4	0.92	9-10	6.09	15-16	5.18	21-22	4.28
4-5	0.55	10-11	4.69	16-17	6.23	22-23	3.20
5-6	0.74	11-12	5.73	17-18	6.93	23-24	2.94

The computer dialogue for this problem is shown in Figure 6-2. The total annual delay is 5019 hours. The average delay per operation is 1.2 minutes.

Example 3

For the conditions given in Example 1, compute the annual demand that produces an average delay of 1.0 minutes per operation.

The following additional runs were made for the conditions given in example 1. The results were:

Annual Demand	Average Annual Delay
200,000 operations	0.42 minutes
250,000 operations	0.73 minutes
265,000 operations	0.92 minutes
270,000 operations	1.07 minutes
275,000 operations	1.22 minutes
300,000 operations	1.94 minutes

From these results, an annual demand of approximately 267,500 operations will produce an average annual delay per operation of 1.0 minutes.

Example 4

For the conditions given in Example 1, compute the average delay per operation in VFR for the single runway for the following 4 consecutive hours.

Hour	Demand	Demand Distribution
15-16	40	22%
16-17	50	28%
17-18	60	33%
18-19	30	17%

The computer dialogue for this problem is shown in Figure 6-3. The annual demand equals 180 x 365 = 65,700 operations. The average delay is 1.34 minutes per operation.

COMPUTER DIALOGUE FOR EXAMPLE 1
FIGURE C-1

G:: and

*** COMPUTERIZED ANNUAL DELAY ***
VERSION 1 (MAY 1976)

```
ENTER ANNUAL DEMAND
200000

ENTER FOR EVERY MONTH:
  PERCENT OF ANNUAL DEMAND
  PERCENT OF MONTH WHICH IS VFR, IFR,
  AND PVC

JANUARY
b,a

ENTER IFR AND PVC OPERATIONS AS A
PERCENT OF VFR OPERATIONS
90,90

ENTER DAILY OPERATIONS AS A
PERCENT OF WEEKLY OPERATIONS

MONDAY
d

ENTER HOURLY OPERATIONS AS A
PERCENT OF DAILY OPERATIONS

 0- 1
L

ENTER DEMAND PROFILE FACTOR
40

ENTER THE FOLLOWING FOR EVERY VFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF VFR DAYS USED
1-
1,120,54,10
2-
2,120,77,50
3-
43,120,75,40

ENTER THE FOLLOWING FOR EVERY IFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF IFR DAYS USED
1-
1,120,52,30
2-
2,120,60,45
3-
43,120,59,25

ENTER THE FOLLOWING FOR EVERY PVC RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF PVC DAYS USED
1-
```

1,120,50,100

FIGURE 6-1 (Cont.)

*** INPUT SUMMARY ***
COMPUTERIZED ANNUAL DELAY
VERSION 1 (MAY 1976)

ANNUAL OPERATIONS 200000

MONTH	% OF ANNUAL OPERATIONS	MONTHLY WEATHER % VFR	IFR	PVC
JAN	8.0	98.	2.	0.
FEB	7.6	98.	2.	0.
MAR	8.1	98.	2.	0.
APR	8.0	99.	1.	0.
MAY	8.2	99.	1.	0.
JUN	8.7	***	0.	0.
JUL	8.8	***	0.	0.
AUG	8.9	***	0.	0.
SEP	8.7	***	0.	0.
OCT	8.7	99.	1.	0.
NOV	8.2	98.	2.	0.
DEC	8.1	99.	1.	0.

DAILY OPERATIONS (IFR DAY)/(VFR DAY) = 90.0%
DAILY OPERATIONS (PVC DAY)/(VFR DAY) = 90.0%

DAILY OPERATIONS AS A PERCENT OF WEEKLY OPN.

MON	TUES	WED	THU	FRI	SAT	SUN
15.0	12.0	12.0	13.0	18.0	14.0	16.0

HOURLY OPNS AS A PERCENT OF DAILY OPNS

0- 1	2.3	6- 7	1.5	12-13	5.3	18-19	6.5
1- 2	1.8	7- 8	4.1	13-14	5.6	19-20	6.7
2- 3	1.2	8- 9	6.5	14-15	5.2	20-21	5.9
3- 4	0.9	9-10	6.1	15-16	5.2	21-22	4.3
4- 5	0.6	10-11	4.7	16-17	6.2	22-23	3.2
5- 6	0.7	11-12	5.7	17-18	6.9	23-24	2.0

DEMAND PROFILE FACTOR = 40

VFR RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

IFR RUNWAY USAGES

1	120	52.	30.
2	120	60.	45.
43	120	59.	25.

PVC RUNWAY USAGES

```
  1      120             50.        100.
```

FIGURE 6-1 (Cont.)

* *

****

ANNUAL SUMMARY

AVERAGE DELAY (MINUTES) AT LEAST	LESS THAN	DISTRIBUTION PERCENT OCCURRENCE
0.0	0.2	12.585
0.2	0.4	36.868
0.4	0.6	32.344
0.6	0.8	12.539
0.8	1.0	4.049
1.0	1.2	0.203
1.2	1.4	0.005
1.4	1.6	0.362
1.6	1.8	0.339
1.8	2.0	0.101
2.0	3.0	0.603
3.0	4.0	0.057

MEAN OF AVERAGE DELAY = 0.42
STANDARD DEVIATION = 0.19

****

```
 ANNUAL DELAY = 1396.229  HOURS
ANNUAL DEMAND =   200000  OPERATIONS
AVERAGE DELAY =     0.42  MINUTES-AIRCRAFT
```

DO YOU WISH TO DETERMINE ANNUAL DELAY
FOR ANOTHER ANNUAL DEMAND?
y
ENTER ANNUAL DEMAND
300000

*** INPUT SUMMARY ***
COMPUTERIZED ANNUAL DELAY
VERSION 1 (MAY 1976)

ANNUAL OPERATIONS   300000

FIGURE 6-1 (Cont.)

MONTH	% OF ANNUAL OPERATIONS	MONTHLY WEATHER % VFR	IFR	PVC
JAN	8.0	98.	2.	0.
FEB	7.6	98.	2.	0.
MAR	8.1	98.	2.	0.
APR	8.0	99.	1.	0.
MAY	8.2	99.	1.	0.
JUN	9.7	***	0.	0.
JUL	8.8	***	0.	0.
AUG	9.9	***	0.	0.
SEP	8.7	***	0.	0.
OCT	8.7	99.	1.	0.
NOV	8.2	98.	2.	0.
DEC	8.1	99.	1.	0.

DAILY OPERATIONS (IFR DAY)/(VFR DAY) = 90.0%
DAILY OPERATIONS (PVC DAY)/(VFR DAY) = 90.0%

DAILY OPERATIONS AS A PERCENT OF WEEKLY OPN.

MON	TUES	WED	THU	FRI	SAT	SUN
15.0	12.0	12.0	13.0	18.0	14.0	16.0

HOURLY OPNS AS A PERCENT OF DAILY OPNS

0- 1	2.3	6- 7	1.5	12-13	5.3	18-19	6.5
1- 2	1.8	7- 8	4.1	13-14	5.6	19-20	6.7
2- 3	1.2	8- 9	6.5	14-15	5.2	20-21	5.9
3- 4	0.9	9-10	6.1	15-16	5.2	21-22	4.3
4- 5	0.6	10-11	4.7	16-17	6.2	22-23	3.2
5- 6	0.7	11-12	5.7	17-18	6.9	23-24	2.9

DEMAND PROFILE FACTOR = 40

VFR RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

IFR RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	52.	30.
2	120	60.	45.
43	120	59.	25.

PVC RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	50.	100.

* * * * * * * * * * * * * * * * * * * *

****

ANNUAL SUMMARY

FIGURE 6-1 (Cont.)

AVERAGE DELAY (MINUTES) AT LEAST	LESS THAN	DISTRIBUTION PERCENT OCCURRENCE
0.0	0.2	7.154
0.2	0.4	8.939
0.4	0.6	12.317
0.6	0.8	15.616
0.8	1.0	15.977
1.0	1.2	9.168
1.2	1.4	6.597
1.4	1.6	4.772
1.6	1.8	3.386
1.8	2.0	2.232
2.0	3.0	7.152
3.0	4.0	2.280
4.0	5.0	0.552
5.0	6.0	0.283
6.0	7.0	0.150
7.0	8.0	0.307
8.0	9.0	0.113
9.0	10.0	0.120
10.0	11.0	0.044
11.0	12.0	0.292
12.0	13.0	0.130
13.0	14.0	0.327
14.0	15.0	0.057
15.0	16.0	0.168
16.0	17.0	0.068
17.0	18.0	0.008
20.0	21.0	0.062
22.0	23.0	0.063
24.0	25.0	0.070
25.0	26.0	0.133
26.0	27.0	0.070
47.0	48.0	0.298
48.0	49.0	0.151
49.0	50.0	0.149
50.0	51.0	0.067
52.0	53.0	0.176
53.0	54.0	0.199
54.0	55.0	0.355

MEAN OF AVERAGE DELAY = 1.94
STANDARD DEVIATION = 2.50

****

ANNUAL DELAY = 9696.730 HOURS
ANNUAL DEMAND = 300000 OPERATIONS
AVERAGE DELAY = 1.94 MINUTES-AIRCRAFT

DO YOU WISH TO DETERMINE ANNUAL DELAY
FOR ANOTHER ANNUAL DEMAND?

COMPUTER DIALOGUE FOR EXAMPLE 2
FIGURE C-2

```
c: and

        *** COMPUTERIZED ANNUAL DELAY ***
              VERSION 1 (MAY 1970)

ENTER ANNUAL DEMAND
250000

ENTER FOR EVERY MONTH:
  PERCENT OF ANNUAL DEMAND
  PERCENT OF MONTH WHICH IS VFR, IFR,
  AND PVC

JANUARY
9.1 91 9 0

FEBRUARY
9.4 90 10 0

MARCH
9.4 91 9 0

APRIL
9.4 87 13 0

MAY
8.0 90 10 0

JUNE
8990 10 0

FIRST DATA ITEM IS NOT A NUMBER OR LETTER A TO G,
INPUT DATA AGAIN

JUNE
7.4 89 11 0

JULY
7.7 84 16 0

AUGUST
7.4 87 13 0

SEPTEMBER
7.4 86 14 0

OCTOBER
8.0 86 14 0

NOVEMBER
8.1 87 13 0

DECEMBER
8.7 89 11 0

ENTER IFR AND PVC OPERATIONS AS A
PERCENT OF VFR OPERATIONS
100 100
```

ENTER DAILY OPERATIONS AS A
PERCENT OF WEEKLY OPERATIONS.

MONDAY
14

TUESDAY
16

WEDNESDAY
14

FIGURE 6-2 (Cont.)

THURSDAY
15

FRIDAY
15

SATURDAY
13

SUNDAY
13

ENTER HOURLY OPERATIONS AS A
PERCENT OF DAILY OPERATIONS

0- 1
2.27

1- 2
1.1a

DATA ITEM IS NOT A NUMBER OR LETTER A TO I, INPUT DATA AGAIN

1- 2
1.81

2- 3
1.19

3- 4
.92

4- 5
.55

5- 6
.74

6- 7
1.53

7- 8
4.11

8- 9
6.47

9-10
6.09

10-11
4.69

```
11-12
5.74a

DATA ITEM IS NOT A NUMBER OR LETTER A TO I, INPUT DATA AGAIN

11-12
5.73

12-13
5.23

13-14
5.56

14-15
5.16

15-16
5.18

16-17
6.23

17-18
6.93

18-19
6.51

19-20
6.69

20-21
5.94

21-22
4.23

22-23
3.2

23-24
2.94

ENTER DEMAND PROFILE FACTOR
40

ENTER THE FOLLOWING FOR EVERY VFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF VFR DAYS USED
1-
1 120 54 10
2-
2 120 77 50
3-
43 120 75 40

ENTER THE FOLLOWING FOR EVERY IFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF IFR DAYS USED
1-
1 120 52 30
2-
2 120 60 45
3-
```

FIGURE 6-2 (Cont.)

43 120 40 25

ENTER THE FOLLOWING FOR EVERY PVC RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF PVC DAYS USED
1-
1,50,50,100

FIGURE 6-2 (Cont.)

*** INPUT SUMMARY ***
COMPUTERIZED ANNUAL DELAY
VERSION 1 (MAY 1976)

ANNUAL OPERATIONS 250000

MONTH	% OF ANNUAL OPERATIONS	MONTHLY WEATHER % VFR	IFR	PVC
JAN	9.1	91.	9.	0.
FEB	9.4	90.	10.	0.
MAR	9.4	91.	9.	0.
APR	9.4	87.	13.	0.
MAY	8.0	90.	10.	0.
JUN	7.4	89.	11.	0.
JUL	7.7	84.	16.	0.
AUG	7.4	87.	13.	0.
SEP	7.4	86.	14.	0.
OCT	8.0	86.	14.	0.
NOV	8.1	87.	13.	0.
DEC	8.7	89.	11.	0.

DAILY OPERATIONS (IFR DAY)/(VFR DAY) =100.0%
DAILY OPERATIONS (PVC DAY)/(VFR DAY) =100.0%

DAILY OPERATIONS AS A PERCENT OF WEEKLY OPN.

MON	TUES	WED	THU	FRI	SAT	SUN
14.0	16.0	14.0	15.0	15.0	13.0	13.0

HOURLY OPNS AS A PERCENT OF DAILY OPNS

0- 1	2.3	6- 7	1.5	12-13	5.3	18-19	6.5
1- 2	1.8	7- 8	4.1	13-14	5.6	19-20	6.7
2- 3	1.2	8- 9	6.5	14-15	5.2	20-21	5.9
3- 4	0.9	9-10	6.1	15-16	5.2	21-22	4.3
4- 5	0.6	10-11	4.7	16-17	6.2	22-23	3.2
5- 6	0.7	11-12	5.7	17-18	6.9	23-24	2.9

DEMAND PROFILE FACTOR = 40

VFR RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

IFR RUNWAY USAGES

1	120	52.	30.
2	120	60.	45.
43	120	40.	25.

FIGURE 6-2 (Cont.)

PVC RUNWAY USAGES

1	50	50.	100.

****

ANNUAL SUMMARY

AVERAGE DELAY (MINUTES) AT LEAST	LESS THAN	DISTRIBUTION PERCENT OCCURRENCE
0.0	0.2	3.778
0.2	0.4	14.158
0.4	0.6	24.796
0.6	0.8	20.707
0.8	1.0	13.139
1.0	1.2	5.639
1.2	1.4	2.105
1.4	1.6	1.751
1.6	1.8	1.354
1.8	2.0	1.034
2.0	3.0	2.420
3.0	4.0	1.037
4.0	5.0	0.438
5.0	6.0	0.417
6.0	7.0	0.153
7.0	8.0	0.360
8.0	9.0	0.148
9.0	10.0	0.095
10.0	11.0	0.109
11.0	12.0	0.195
12.0	13.0	0.069
13.0	14.0	0.086
18.0	19.0	0.026
19.0	20.0	0.073
45.0	46.0	0.066
46.0	47.0	0.055
47.0	48.0	0.217
48.0	49.0	0.122
51.0	52.0	0.195
54.0	55.0	0.036
56.0	57.0	0.131
63.0	64.0	0.044

MEAN OF AVERAGE DELAY = 1.20
STANDARD DEVIATION = 1.74

```
*********************************************************************

                    ANNUAL DELAY = 5019.008  HOURS
                   ANNUAL DEMAND =   250000  OPERATIONS
                   AVERAGE DELAY =     1.20  MINUTES-AIRCRAFT


DO YOU WISH TO DETERMINE ANNUAL DELAY
FOR ANOTHER ANNUAL DEMAND?
no

DO YOU WISH TO PERFORM ANOTHER CALCULATION?
no
```

FIGURE 6-2 (Cont.)

COMPUTER DIALOGUE FOR EXAMPLE 8
FIGURE C-3

ex and

*** COMPUTERIZED ANNUAL DELAY ***
VERSION 1 (MAY 1976)

```
ENTER ANNUAL DEMAND
65700

ENTER FOR EVERY MONTH:
  PERCENT OF ANNUAL DEMAND
  PERCENT OF MONTH WHICH IS VFR, IFR,
  AND PVC

JANUARY
a,a

ENTER IFR AND PVC OPERATIONS AS A
PERCENT OF VFR OPERATIONS
100,100

ENTER DAILY OPERATIONS AS A
PERCENT OF WEEKLY OPERATIONS

MONDAY
a

ENTER HOURLY OPERATIONS AS A
PERCENT OF DAILY OPERATIONS

 0- 1
0

 1- 2
0

 2- 3
0

 3- 4
0

 4- 5
0

 5- 6
0

 6- 7
0

 7- 8
0

 8- 9
0

 9-10
0
```

10-11
0

11-12
0

12-13
0

13-14
0

14-15
0

FIGURE 6-3 (Cont.)

15-16
22

16-17
28

17-18
33

18-19
17

19-20
0

20-21
0

21-22
0

22-23
0

23-24
0

ENTER DEMAND PROFILE FACTOR
40

ENTER THE FOLLOWING FOR EVERY VFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF VFR DAYS USED
1-
1,120,54,10
2-
2,120,77,50
3-
43,120,75,40

ENTER THE FOLLOWING FOR EVERY IFR RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF IFR DAYS USED
1-
1,120,54,10
2-
2,120,77,50
3-
43,120,75,40

ENTER THE FOLLOWING FOR EVERY PVC RUNWAY USE:
RUNWAY USE DIAGRAM NUMBER FROM FIGURE 2-2, MIX INDEX,
HOURLY RUNWAY CAPACITY, AND PERCENT OF PVC DAYS USED
1-
1,120,54,10
2-
2,120,77,50
3-
43,120,75,40

FIGURE 6-3 (Cont.)

*** INPUT SUMMARY ***
COMPUTERIZED ANNUAL DELAY
VERSION 1 (MAY 1976)

ANNUAL OPERATIONS 65700

MONTH	% OF ANNUAL OPERATIONS	MONTHLY WEATHER % VFR	IFR	PVC
JAN	8.3	98.	2.	0.
FEB	8.3	98.	2.	0.
MAR	8.3	98.	2.	0.
APR	8.3	99.	1.	0.
MAY	8.3	99.	1.	0.
JUN	8.4	***	0.	0.
JUL	8.4	***	0.	0.
AUG	8.4	***	0.	0.
SEP	8.4	***	0.	0.
OCT	8.3	99.	1.	0.
NOV	8.3	98.	2.	0.
DEC	8.3	99.	1.	0.

DAILY OPERATIONS (IFR DAY)/(VFR DAY) =100.0%
DAILY OPERATIONS (PVC DAY)/(VFR DAY) =100.0%

DAILY OPERATIONS AS A PERCENT OF WEEKLY OPN.

MON	TUES	WED	THU	FRI	SAT	SUN
14.2	14.3	14.3	14.3	14.3	14.3	14.3

HOURLY OPNS AS A PERCENT OF DAILY OPNS

0- 1	0.0	6- 7	0.0	12-13	0.0	18-19	17.0
1- 2	0.0	7- 8	0.0	13-14	0.0	19-20	0.0
2- 3	0.0	8- 9	0.0	14-15	0.0	20-21	0.0
3- 4	0.0	9-10	0.0	15-16	22.0	21-22	0.0
4- 5	0.0	10-11	0.0	16-17	28.0	22-23	0.0
5- 6	0.0	11-12	0.0	17-18	33.0	23-24	0.0

DEMAND PROFILE FACTOR = 40

VFR RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

IFR RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

PVC RUNWAY USAGES

FIG NO.	MIX INDEX	HOURLY CAPACITY	% DAYS USED
1	120	54.	10.
2	120	77.	50.
43	120	75.	40.

FIGURE 6-3 (Cont.)

*

****

ANNUAL SUMMARY

AVERAGE DELAY (MINUTES) AT LEAST	LESS THAN	DISTRIBUTION PERCENT OCCURRENCE
0.2	0.4	11.797
0.4	0.6	17.210
0.6	0.8	5.003
0.8	1.0	10.557
1.0	1.2	6.655
1.2	1.4	8.060
1.4	1.6	13.637
1.6	1.8	6.520
1.8	2.0	1.477
2.0	3.0	2.376
3.0	4.0	1.357
4.0	5.0	0.[illegible]7
6.0	7.0	0.551
7.0	8.0	0.018
8.0	9.0	0.096

MEAN OF AVERAGE DELAY = 1.34
STANDARD DEVIATION = 0.[illegible]5

****

```
  ANNUAL DELAY = 1468.914  HOURS
 ANNUAL DEMAND =    65700  OPERATIONS
 AVERAGE DELAY =     1.34  MINUTES-AIRCRAFT


DO YOU WISH TO DETERMINE ANNUAL DELAY
FOR ANOTHER ANNUAL DEMAND?
no

DO YOU WISH TO PERFORM ANOTHER CALCULATION?
no
```

FIGURE 6-3 (Cont.)

CHAPTER 7 - ON-LINE ANNUAL SERVICE VOLUME MODEL VERSION 1 - ANNUAL SERVICE VOLUME

7.1 Introduction

The On-line Annual Service Volume Model is a tutorial program for calculating annual service volume. It is similar in operation to the On-line Runway Capacity Model discussed in Chapter 3.

Annual service volume is a measure of the annual capacity of an airport. Annual service volume is not a saturation capacity but rather a level of service capacity. In developing the Annual Service Volume Model contained in this chapter, the following level of service criteria were used:

a. As annual demand approaches annual service volume, delay to aircraft starts to increase rapidly.

b. When annual demand equals annual service volume, a reasonable level of service exists for much of the year.

c. When annual demand is 20 percent more than annual service volume, the airport will experience severe congestion.

Annual service volume is useful as a guide to determine the need for more specific analysis, and as a preliminary planning analysis that may be useful in the National Aviation System Plan (NASP) or state and regional system plans. It is not meant as a replacement for detailed hourly evaluation of complex airport operations, and should not be the sole justification for airfield improvements, entrance into the Airport Development Aid Program (ADAP) or other allocations of financial resources.

A list of computer services (or timesharing companies) offering the program can be obtained from:

Chief, Airport Design Branch, ARD-410
2100 Second Street, S.W.
Washington, D.C. 20590

(202) 426-3685

7.2 Model Logic

Annual service volume is computed by the following deterministic equation:

$$\text{Annual Service Volume} = \frac{Cw \times ATD \times 100}{DTD \times H}$$

where

CW is the weighted hourly capacity, computed by

$$Cw = \frac{\sum_{i=1}^{N} Ci\ Wi\ Pi}{\sum_{i=1}^{N} Wi\ Pi}$$

where Pi is the proportion of the year with capacity Ci, and Wi is the weight to be applied to Ci values. Wi values are determined from the following table:

Percent of Maximum Capacity	Weight Wi VFR 0-300	IFR Mix Index 0-20	IFR Mix Index 21-50	IFR Mix Index 51-300
90-100	1	1	1	1
81-90	5	1	3	5
66-80	15	2	8	15
51-65	20	2	12	20
0-50	25	4	16	25

H is the percent of the daily demand that occurs in the peak hour.

ATD is the annual traffic demand.

DTD is the daily traffic demand for the average day of the peak month.

The factor 100/H extends an hourly capacity to a daily capacity. The factors ATD/DTD extends the daily capacity to an annual capacity.

The weighting factors Wi were established emperically to give annual delays per aircraft of 2 to 4 minutes. The mix index used in association with the Wi factors is %C + 3%D, where C & D aircraft are defined in Figure 1-1. The Wi factors are related to the percent of maximum capacity to account for the disproportionately large impact on delay of a low hourly capacity used a small percent of the time. The same Wi factors are used for IFR and PVC.

7.3 Input Format

The following is a detailed description of the data requests and the acceptable inputs for the On-line Annual Service Volume Model:

ENTER THE NUMBER OF RUNWAY USE CONFIGURATIONS TO BE CONSIDERED.

This data request is typed after the program identification code is entered (e.g., EXECUTE ASV.RDL). Allowable inputs are 1 through 25.

FOR RUNWAY USE CONFIGURATION NUMBER 1

HC =
% =
W =
MI =

HC is the hourly capacity of the runway use configuration.
% is the utilization percent of the runway use configuration.
W is the weather code for the runway capacity.
MI is the mix index associated with the runway use configuration.

Allowable inputs for HC are 0 through 400. If HC is negative, the run will be aborted.

Allowable inputs for % are 1 through 100. If % is negative, the run will be aborted.

Allowable inputs for W are:

1 for VFR
2 for IFR
3 for PVC

Allowable inputs for MI are 0 through 180.

This series of questions will be repeated for each runway use configuration. If the summation of % over all runway use configurations does not equal 100, the user will be requested to reenter % for each runway use configuration.

ENTER THE PERCENT OF THE DAILY DEMAND THAT OCCURS IN THE PEAK HOUR.

Allowable inputs are 4 through 20.

ENTER THE ANNUAL TRAFFIC DEMAND.

Allowable inputs are 1000 through 1,000,000.

ENTER THE DAILY TRAFFIC DEMAND FOR THE AVERAGE DAY OF THE PEAK MONTH.

Allowable inputs are 0 through 4000.

7.4 Input Considerations

The following factors should be considered in determining annual service volume:

a. Operating Period. The percent utilization for each runway use configuration should be based on conditions that occur during potentially busy hours. In general, late night and early morning hours have very low demands and thus tend to employ runway use configurations that have lower capacities. Every effort should be made to eliminate these low runway use configurations from the analysis. For example, if the VFR capacity between 7 a.m. and 10 p.m. was 140 operations per hour in VFR and 110 operations in IFR, and the capacity between 10 p.m. and 7 a.m. was 70 operations per hour because the traffic demand did not require the use of all runways, the annual service volume should be based on the percent occurrance of the VFR and IFR capacities between 7 a.m. and 10 p.m.

b. Maintenance. In determining the percent utilization of each runway use configuration consideration should be given to the fact that runways will be down periodically for maintenance. This will tend to decrease the percent utilization of high capacity runway use configurations and increase the percent utilization of low capacity runways.

c. Daily and Annual Demand. To compute annual service volume requires information on annual traffic demand (ATD) and the demand for the average day of the peak month (DTD). If these values are not available from records, they can be arrived at by setting the ratio (R) of ATD/DTD equal to the equivalent number of busy days during the year. Airports with a high percent of commerical aircraft tend to have a ratio of around 340. Airports with a high percent of general aviation aircraft tend to have a ratio of around 280. After having determined the equivalent number of busy days, the model input for DTD should be set equal to 1000 and ATD would then be 1000 x R.

d. Peaking Hour Characteristics. If the percent of the daily demand that occurs in the peak hour is unknown, H can be approximated by:

$$H = (1/N) \times 100$$

where

N = Number of hours in which 90% of the daily demand occurs.

7.5 Output

When the questions described in paragraph 7.3 have been answered, the program will print the annual service volume in operations per year. At this point, it is possible to do parametric variations of the last three questions of paragraph 7.3 without reentering the hourly capacity information for each runway use configuration.

> DO YOU WANT TO MAKE ANOTHER CALCULATION WITH THE SAME RUNWAY USE CAPACITIES AS BEFORE?

If YES or Y is entered, the sequence of questions starting with ENTER THE PERCENT OF THE DAILY DEMAND THAT OCCURS IN THE PEAK HOUR will be repeated. If NO or N is entered, the following question is asked:

> DO YOU WANT TO COMPUTE ADDITIONAL ANNUAL SERVICE VOLUME?

If YES or Y is entered, the sequence of questions starting with ENTER THE NUMBER OF RUNWAY USE CONFIGURATIONS TO BE CONSIDERED will be repeated. If NO or N is entered, execution of the annual service volume program will be terminated.

The calculated annual service volume assumes that the airport is open 100% of the year. If the airport is closed Z percent of the year due to inclement weather, the annual service volume should be adjusted downward as follows:

$$\text{True ASV} = \text{ASV}(100 - Z)/100$$

7.6 Examples

The following example illustrates the use of the On-line Annual Service Volume Model Version 1:

Example 1

Compute the annual service volume (ASV) for the following conditions:

> Annual demand = 115,200 and 137,400 operations
> Demand on average day of peak month = 627 operations
> Demand in peak hours = 10% of daily demand

Runway Geometry	Diagram Number	Mix Index	Weather	Hourly Capacity	Percent Utilization
Single	1	120	VFR	54	3
Parallel	2	120	VFR	77	45
Intersecting	43	120	VFR	75	30
Single	1	150	IFR	50	7
Parallel	2	150	IFR	60	5
Intersecting	43	150	IFR	60	5
Single	1	180	PVC	44	5

The computer dialogue for this problem is shown in Figure 7-1. The annual service volume is 129,475 operations when the annual demand is 115,200 and 154,427 when the annual demand is 137,400.

7.7 Program Listing

```
type asv.sfo
DIMENSION HC(25),P(25),WE(25),MI(25),MAXPC(25),PHC(25),N(25)
INTEGER ASV
REAL P,PHC,HC,MAXHC
STRING Q1(5),Q2(5)
DISPLAY '                ANNUAL SERVICE VOLUME'
DISPLAY '                   COMPUTATION PROGRAM'
DISPLAY '                      ASV VERSION 1'
DISPLAY ' '
DISPLAY ' '
DISPLAY ' DEFINATION OF INPUT TERMS USED IN THIS PROGRAM:'
DISPLAY '   HC=HOURLY RUNWAY CAPACITY OF A SPECIFIED RUNWAY USE CONF.'
DISPLAY '   %= UTILIZATION PERCENT OF A SPECIFIED RUNWAY USE CONF.'
DISPLAY '   W= WEATHER CODE;  VFR=1, IFR=2, PVC=3'
DISPLAY '   MI=MIX INDEX= %C+%3D'
DISPLAY' '
DISPLAY ' '
 700 ACCEPT' ENTER THE NUMBER OF RUNWAY USE CONFIGURATIONS TO BE CONSIDE
**RED. ',N
IF(N.GT.25) DISPLAY'THE NUMBER OF RUNWAY USE CONFIGURATIONS FOR THIS
                                                                   CALC
ULATION PROGRAM CAN NOT EXCEED 25.'
IF(N.GT.25) GOTO 700
DO 10 I=1,N,1
DISPLAY ' '
DISPLAY ' FOR RUNWAY USE CONF. NUMBER ',I
 710 ACCEPT '      HC= ',HC(I)
IF(HC(I).GT.400)DISPLAY'WARNING: AN HOURLY CAPACITY OF ',HC(I), 'IS
                                                                   VERY
 UNLIKELY.  PLEASE REENTER.'
IF (HC(I).GT.400) GOTO 710
IF(HC(I).LT.0)DISPLAY'RUN ABORTED'
IF(HC(I).LT.0) GOTO 610
 720 ACCEPT '      %= ',P(I)
IF(P(I).GT.100)DISPLAY' WARNING: UTILIZATION PERCENT MUST BE LESS
                                                                 THAN 1
00.  PLEASE REENTER.'
IF(P(I).GT.100) GOTO 720
IF(P(I).LT.1) DISPLAY' WARNING:  INPUT IS IN PERCENT (EX 40 ) NOT
                                                                  DECIMA
L (EX .40).  PLEASE REENTER'
IF(P(I).LT.1) GOTO 720
IF(P(I).LT.0) DISPLAY' RUN ABORTED'
IF(P(I).LT.0)     GOTO 610
 730 ACCEPT '      W= ',WE(I)
IF (WE(I).GT.3)DISPLAY ' WEATHER INPUT IS 1 FOR VFR, 2 FOR IFR, AND 3 FO
**R PVC.  PLEASE REENTER. '
IF (WE(I).GT.3) GOTO 730
 740 ACCEPT '      MI= ',MI(I)
 10 CONTINUE
```

```
DISPLAY ' '
750 T=0
DO 11 I=1,N,1
T=P(I)+T
11 CONTINUE
IF(T.NE.100)DISPLAY'SUMMATION OF UTILIZATION PERCENT DOES
                                                    NOT EQUAL 100.
 PLEASE REENTER',
              . ' UTILIZATION
                              PERCENT FOR EACH RUNWAY USE CONFIGURATION.'
IF(T.EQ.100) GOTO 760
DO 12 I=1,N,1
DISPLAY' '
DISPLAY 'FOR RUNWAY USE CONF. NUMBER ',I
ACCEPT    '%= ',P(I)
DISPLAY' '
12 CONTINUE
GOTO 750
 760 Z=0
DISPLAY' '
DO 200 I=1,N,1
IF (HC(I).GT.Z) Z=HC(I)
200 CONTINUE
MAXPC(I)=Z
DO 210 I=1,N,1
PHC(I)=(HC(I)/Z)*100
210 CONTINUE
DO 500 I=1,N,1
IF(WE(I).EQ.1) GOTO 300
IF(WE(I).NE.1) GOTO 400
 300 IF(PHC(I).GE.90)W(I)=1;
IF(PHC(I).GE.81)  W(I)=5
IF(PHC(I).GE.66)W(I)=15;
IF(PHC(I).GE.51) W(I)=20
IF (PHC(I).LT.51) W(I)=25
GOTO 500
 400 IF (MI(I).GT.50)GOTO 410
IF (MI(I).GT.20) GOTO420
410 IF(PHC(I).GE.90)W(I)=1
IF(PHC(I).GE.81)W(I)=5
IF(PHC(I).GE.66)W(I)=15
IF(PHC(I).GE.51) W(I)=20
IF(PHC(I).LT.51) W(I)=25
GOTO 500
420IF(PHC(I).GE.90)W(I)=1
IF(PHC(I).GE.81)W(I)=3
IF(PHC(I).GE.66)W(I)=8
IF(PHC(I).GE.51) W(I)=12
IF(PHC(I).LT.51) W(I)=16
GOTO 500
430IF(PHC(I).GE.90)W(I)=1
IF(PHC(I).GE.81)W(I)=1
IF(PHC(I).GE.66)W(I)=2
IF(PHC(I).GE.51) W(I)=3
IF(PHC(I).LT.51) W(I)=4
GOTO 500
500 CONTINUE
```

```
X=0
Y=0
DO 100 I=1,N,1
X=(HC(I)*W(I)*P(I))+X
Y=(W(I)*P(I))+Y
100 CONTINUE
CW=X/Y
600 CONTINUE
 620 ACCEPT' ENTER THE PERCENT OF THE DAILY DEMAND THAT OCCURS
                                                                    IN THE PEA
K HOUR.  ',H
IF (H.LT.4)DISPLAY'WARNING: THE PERCENT OF DAILY DEMAND THAT OCCURS
                                                                          IN T
HE PEAK HOUR CAN NOT',
                           ' BE LESS THAN 4%.  PLEASE REENTER.'
IF(H.LT.4) GOTO 620
IF(H.GT.20)DISPLAY'WARNING:  THE PERCENT OF THE DAILY DEMAND THAT OCCURS
** IN THE PEAK HOURS','WOULD NOT LIKELY EXCEED 20% UNDER NORMAL CONDITIONS.PLEASE
** REENTER.'
IF(H.GT.20) GOTO 620
 630 ACCEPT' ENTER THE ANNUAL TRAFFIC DEMAND.  ',ATD
IF(ATD.LT.1000)DISPLAY' WARNING:  AN ANNUAL TRAFFIC DEMAND OF ',
                                                                    ATD,' OP
ERATIONS PER YEAR IS VERY UNLIKELY.  PLEASE REENTER.  NOTE:
                                                          EXPRESS',' THREE HUN
RED THOUSAND AS 300000 NOT 300.'
IF(ATD.LT.1000)GOTO 630
IF(ATD.GT.1000000)DISPLAY'  WARNING:  AN ANNUAL TRAFFIC DEMAND
                                                                    OF ',ATD,'
 IS VERY UNLIKELY.  PLEASE REENTER.'
IF(ATD.GT.1000000) GOTO 630
 640 ACCEPT ' ENTER THE DAILY TRAFFIC DEMAND FOR THE AVERAGE DAY OF THE
**PEAK MONTH.
               ',DTD
IF (DTD.GT.4000)DISPLAY'WARNING:  A DAILY DEMAND OF ',DTD,' IS VERY
                                                                         UNLIK
ELY.  PLEASE REENTER.'
IF(DTD.GT.4000) GOTO 640
ASV=CW*(ATD/DTD)*(100/H)
DISPLAY ' '
DISPLAY '**********************************************************'
DISPLAY' ANNUAL SERVICE VOLUME= ',ASV,'OPERATIONS PER YEAR'
ACCEPT'DO YOU WANT TO MAKE ANOTHER CALCULATION WITH THE SAME RUNWAY',
**USE CAPACITIES AS BEFORE?  ',Q1
IF(Q1.EQ.'YES'.OR.Q1.EQ.'Y') GOTO 600
 610 ACCEPT'DO YOU WANT TO COMPUTE ADDITIONAL ASV?  ',Q2
IF(Q2.EQ.'YES'.OR.Q2.EQ.'Y') GOTO 700
END
```

COMPUTER DIALOGUE FOR EXAMPLE 1

FIGURE 7-1

```
execute asv.rdl
LOADING
EXECUTION
                 ANNUAL SERVICE VOLUME
                   COMPUTATION PROGRAM
                     ASV VERSION 1


 DEFINATION OF INPUT TERMS USED IN THIS PROGRAM:
   HC=HOURLY RUNWAY CAPACITY OF A SPECIFIED RUNWAY USE CONF.
   %= UTILIZATION PERCENT OF A SPECIFIED RUNWAY USE CONF.
   W= WEATHER CODE;  VFR=1, IFR=2, PVC=3
   MI=MIX INDEX= %C+%3D


 ENTER THE NUMBER OF RUNWAY USE CONFIGURATIONS TO BE CONSIDERED. 7

 FOR RUNWAY USE CONF. NUMBER      1
      HC= 54
      %= 3
      W= 1
      MI= 120

 FOR RUNWAY USE CONF. NUMBER      2
      HC= 77
      %= 45
      W= 1
      MI= 120

 FOR RUNWAY USE CONF. NUMBER      3
      HC= 75
      %= 30
      W= 1
      MI= 120

 FOR RUNWAY USE CONF. NUMBER      4
      HC= 50
      %= 7
      W= 2
      MI= 150

 FOR RUNWAY USE CONF. NUMBER      5
      HC= 60
      %= 5
      W= 2
      MI= 150

 FOR RUNWAY USE CONF. NUMBER      6
      HC= 60
      %= 5
      W= 2
      MI= 150
```

```
FOR RUNWAY USE CONF. NUMBER        7
     HC= 44
     %= 5
     W= 3
     MI= 180

 ENTER THE PERCENT OF THE DAILY DEMAND THAT OCCURS

IN THE PEAK HOUR.  10
 ENTER THE ANNUAL TRAFFIC DEMAND.  115200
 ENTER THE DAILY TRAFFIC DEMAND FOR THE AVERAGE DAY OF THE PEAK MONTH.

  627

*****************************************************
 ANNUAL SERVICE VOLUME=      129475  OPERATIONS PER YEAR
DO YOU WANT TO MAKE ANOTHER CALCULATION WITH THE SAME RUNWAY  USE CAPACITIES
BEFORE?  y
 ENTER THE PERCENT OF THE DAILY DEMAND THAT OCCURS

IN THE PEAK HOUR.  10
 ENTER THE ANNUAL TRAFFIC DEMAND.  137400
 ENTER THE DAILY TRAFFIC DEMAND FOR THE AVERAGE DAY OF THE PEAK MONTH.

  627

*****************************************************
 ANNUAL SERVICE VOLUME=      154427  OPERATIONS PER YEAR
DO YOU WANT TO MAKE ANOTHER CALCULATION WITH THE SAME RUNWAY  USE CAPACITIES
BEFORE?  no
DO YOU WANT TO COMPUTE ADDITIONAL ASV?  n
```

FIGURE 7-1 (Cont.)

APPENDIX A PERCENT ARRIVAL TECHNIQUE MODEL

A.1 Introduction

This appendix presents a utility on-line program for computing percent arrival. This technique can be used to:

a) Compute the capacity of a runway use configuration for a given percent arrival.

b) Compute the capacity of some runway use configurations not shown in Figure 2-1.

c) Produce capacity versus percent arrival sensitivity curves with only one run of the Runway Capacity Model.

Copies of this utility program are not available for distribution. A listing of the program is contained in paragraph A.6. The model is currently available for use on TYMSHARE.

A.2 Model Logic

The percent arrival technique is based on the capacity of a basic runway use configuration and a revised runway use configuration. The basic runway use configuration is defined as the input runway use configuration with preemptive arrival priority. The revised runway use configuration is defined as an operational subset of the basic runway use configuration which is used to bring departure capacity up to the desired proportion of arrival capacity. The revised runway use configuration is determined by eliminating all stream(s) that could influence the departure stream(s). For example, if the basic runway use configuration was mixed operations on a single runway (i.e., Model 1-3), the revised runway use configuration would be departures only on a single runway (i.e., Model 1-2). Figure A-1 contains a listing of revised runway use configurations (in terms of model numbers) that may be used with basic runway use configurations.

The model logic is as follows:

If PA = desired percent arrivals.
A1 = arrival capacity of the basic runway use configuration.
D1 = departure capacity of the basic runway use configuration.
A2 = arrival capacity of the revised runway use configuration with all arrival stream(s) eliminated which could influence departure stream(s).
D2 = departure capacity of revised runway use configura-

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tion with all arrival stream(s) eliminated which could influence departure capacity.

Check the inequality

$$PA \geq \frac{A1}{A1+D1} \qquad (1)$$

If this inequality holds, then

CAPACITY = A1/PA

and the percent arrivals is PA as specified.

If inequality (1) does not hold, check the inequality

$$PA \geq \frac{A2}{A2 + D2} \qquad (2)$$

If this inequality holds, compute

$$p = \frac{(A2 + D2)\ PA - A2}{(A1 - A2) + (A2 + D2 - (A1 + D1))\ PA}$$

where p is the proportion of time the basic runway use applies and 1 - p is the proportion of time the revised runway use applies.

Now

CAPACITY = (A1 + D1) p + (A2 + D2) (1 - p)

and the percent ar ıls is PA as specified.

If inequality (2) does not hold, compute

$$CAPACITY = \frac{D2}{1 - PA}$$

and percent arrivals is PA as specified.

A.3 Input Format

The percent arrival technique can be executed via the command EXECUTE PA.SFO. The first question is:

ENTER DESIRED % ARRIVALS:

Any integer from 0 to 100 can be input. The next question is:

ENTER ARRIVAL CAPACITY OF BASIC RUNWAY USE CONFIGURATION:

This input would come from a run of the Runway Capacity Model for the desired runway use configuration and 9999 entered for percent arrival. Any integer from 0 to 240 can be input. The next question is:

> ENTER DEPARTURE CAPACITY OF BASIC RUNWAY USE CONFIGURATION:

This input would come from a run of the Runway Capacity Model for the desired runway use configuration and 9999 entered for percent arrival. Any integer from 0 to 240 can be input.

If inequality (1) is true, no further input questions will be asked. If inequality (1) is not true, the next question is:

> ENTER ARRIVAL CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL STREAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS.

This input would come from a run of the Runway Capacity Model for the revised runway use configuration and 9999 entered for percent arrival. Any integer from 0 to 240 can be input. The next question is:

> ENTER DEPARTURE CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL STREAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS.

This input would come from a run of the Runway Capacity Model for the revised runway use configuration and 9999 entered for percent arrival. Any integer from 0 to 240 can be entered.

A.4 Output

The output of the percent arrival technique is the total capacity of the runway use configuration for the input percent arrival, and capacities. Following the printing of the total capacity, the model can be used to compute the sensitivity of total capacity to variations of percent arrival:

> DO YOU WANT A SENSITIVITY ANALYSIS OF CAPACITY TO PERCENT ARRIVAL?

A Y or YES response will result in total capacity being computed for values of percent arrival ranging from 0 to 100 in increments of 5%. A N or No response will result in the question:

> DO YOU WANT TO MAKE ANOTHER CALCULATION?

A Y or YES response will result in the question:

ENTER DESIRED % ARRIVALS:

The model will then ask for new values of arrival and departure capacity for the basic and revised runway use configurations. A N or NO response will terminate the program.

A.5 Examples

The following illustrates the use of the on-line program for computing percent arrivals.

Example 1

Compute the hourly capacity for the following conditions:

PA = 45%
A1 = 35 D1 = 15
A2 = 0 D2 = 55

Also, compute the sensitivity of hourly capacity to percent arrivals. The computer dialogue for this problem is shown in Figure A-2. The capacity at 45% arrival is 51 operations per hour. The sensitivity of capacity to percent arrivals is:

Percent Arrivals	Hourly Capacity
0	55
5	55
10	54
15	54
20	53
25	53
30	53
35	52
40	52
45	52
50	51
55	51
60	51
65	50
70	50
75	47
80	44
85	41
90	39
95	37
100	35

Example 2

If an airport is composed of two runway use configurations that are independent from an air traffic control standpoint, compute the hourly capacity at 50% arrivals for the following conditions:

Runway Use Configuration 1		Runway Use Configuration 2	
A1 = 35	D1 = 10	A1 = 35	D1 = 20
A2 = 0	D2 = 55	A2 = 0	D2 = 55

The combined arrival and departure capacities are:

A1 = 70	D1 = 30
A2 = 0	D2 = 110

The computer dialogue for this problem is shown in Figure A-3. The capacity at 50% arrival is found to be 102 operations per hour.

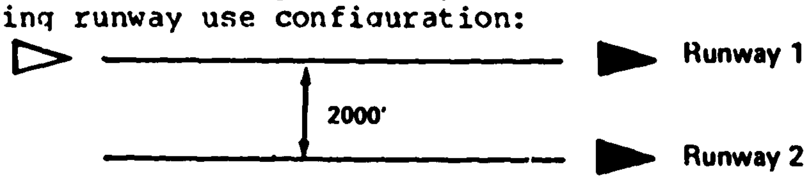
NOTE: If the 50% capacity had been calculated for each runway use configuration separately (computer run not shown), the total capacity would be:

Runway Use Configuration 1 =	48
Runway Use Configuration 2 =	55
Total	103

The difference in total capacity results because combining the arrival and departure components of capacity for both runway use configurations allows Runway Use Configuration 2 to supplement the capacity of Runway Use Configuration 1; i.e., more aircraft are allowed to use Runway Use Configuration 2 than Runway Use Configuration 1.

Example 3

Compute the VFR hourly capacity for 50% arrival of the following runway use configuration:



The operation is such that only 10 departures are permitted to use runway 2 each hour.

The capacity without regard to percent arrival (i.e., 9999 input for percent arrival) for runway 1 is:

ARRIVALS =	35
DEPARTURES =	15
TOTAL	50

The departure only capacity of runway 1 is 60 operations per hour and the departure only capacity of runway 2 is 60 operations per hour.

From this data the model inputs are:

A1 = 35	D1 = 25	i.e., 15 + 10
A2 = 0	D2 = 70	i.e., 60 + 10

The computer dialogue is shown in Figure A-4. The hourly capacity is found to be 61 operations per hour.

NOTE: If the operational restriction was not placed on runway 2, the model inputs would be:

A1 = 35	D1 = 75	i.e., 60 + 15
A2 = 0	D2 = 120	

The capacity would be 70 operations per hour (calculation not shown).

A.6 Program Listing

```
type pa.sfo
      DIMENSION PA(20),A1(20),D1(20),A2(20),D2(20)
       INTEGER CAP
       REAL PA,A1,D1,A2,D2
       STRING S1(6)
      STRING S2(6)
      DISPLAY "    "
      DISPLAY "    "
      DISPLAY "    "
      DISPLAY "    "
      DISPLAY "    "
      DISPLAY "              ****** PERCENT ARRIVALS TECHNIQUE ****** "
      DISPLAY "                     FOR ALL R/W CAPACITY MODELS "
       DISPLAY " "
       DISPLAY " "
      77  DISPLAY ""
       DO 22 I=1,N,1
      DISPLAY "    "
      30  ACCEPT "ENTER DESIRED % ARRIVALS:    ",PA(I)
      IF(PA(I) .LT. 0 .OR. PA(I) .GT. 100) DISPLAY"WARNING: % ARRIVALS MUST B
**E 0-100,PLEASE RE-ENTER"
      PA(I)=PA(I)/100
      IF(PA(I) .LT. 0 .OR. PA(I) .GT. 100) GO TO 30
      40  ACCEPT "ENTER ARRIVAL CAPACITY OF BASIC RUNWAY USE CONFIGURATION:
** ",A1(I)
      IF(A1(I) .GT. 240 .OR. A1(I) .LT. 0) DISPLAY"AN HOURLY ARRIVAL CAPACITY
** OF ",A1(I),"VERY UNLIKELY AND UNUSUAL,PLEASE CHECK AGAIN TO SEE IF THIS IS WH
**AT YOU REALLY WANT, THEN RE-ENTER"
      IF(A1(I) .GT. 240 .OR. A1(I) .LT. 0) GO TO 40
      50  ACCEPT "ENTER DEPARTURE CAPACITY OF BASIC RUNWAY USE CONFIGURATION:
**    ",D1(I)
      IF(D1(I) .GT. 240 .OR. D1(I) .LT. 0) DISPLAY "AN HOURLY DEPARTURE CAPAC
**ITY OF ",D1(I)," IS VERY UNLIKELY"
     IF(D1(I) .GT. 240 .OR. D1(I) .LT. 0) GO TO 50
      DISPLAY " "
      B=A1(I)/(A1(I)+D1(I))
      IF(PA(I) .LT. B) GO TO 60
      CAP=A1(I)/PA(I)
      A2(I)=0
      D2(I)=0
      GO TO 100
      60  ACCEPT "ENTER ARRIVAL CAPACITY OF REVISED RUNWAY USE CONFIGURATION
**WITH ALL ARRIVAL STREAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:
**",A2(I)
      DISPLAY "    "
     IF(A2(I).GT.400) DISPLAY' AN HOURLY ARRIVAL CAPACITY OF',A2(I),'IS VERY
**UNLIKELY, PLEASE CHECK AGAIN AND RE-ENTER.'
      IF(A2(I) .GT. 400) GOTO 60
      65  ACCEPT "ENTER DEPARTURE CAPACITY OF REVISED RUNWAY USE CONFIGURATIO
**N WITH ALL ARRIVAL STREAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:
**  ",D2(I)
      IF(D2(I) .GT. 400 .OR. D2(I) .LT. 1) DISPLAY "AN HOURLY DEPARTURE CAPAC
**ITY OF ",D2(I)," IS VERY UNLIKELY,PLEASE CHECK AGAIN,THEN RE-ENTER"
     IF(D2(I) .GT. 400 .OR. D2(I) .LT. 1) GO TO 65
      35  C=A2(I)/(A2(I)+D2(I))
      IF(PA(I) .LT. C) GO TO 33
```

```
P=A2(I)+D2(I)
G=A1(I)+D1(I)
R=A1(I)-A2(I)
Y=(P*PA(I)-A2(I))/(R+(A2(I)+D2(I)-G)*PA(I))
Z=1-Y
CAP=G*Y+P*(1-Y)                                                    AR
DISPLAY " "
DISPLAY "PROPORTION OF TIME BASIC RUNWAY USE APPLIES = ",Y," "
DISPLAY "PROPORTION OF TIME REVISED RUNWAY USE APPLIES = ",Z," "
DISPLAY " "
DISPLAY " "
DISPLAY " "
DISPLAY "                         (OPTION 1) "
GO TO 100
30 CAP=D2(I)/(1-PA(I))
DISPLAY " "
DISPLAY " "
DISPLAY " "
DISPLAY " "
DISPLAY "                         (OPTION 2) "
100 DISPLAY "          *********************************************
***"
DISPLAY " "
DISPLAY " "
DISPLAY " "
DISPLAY " "
DISPLAY "          CAPACITY = ",CAP," OPERATIONS PER HOUR"
DISPLAY " "
DISPLAY " "
DISPLAY " "
DISPLAY " "
46 ACCEPT "DO YOU WANT A SENSITIVITY ANALYSIS OF PERCENT ARRIVALS TO C
**APACITY?  ",S2
DISPLAY " "
DISPLAY " "
DISPLAY " "
IF(S2 .EQ. "YES" .OR. S2 .EQ. "Y")DISPLAY "     % ARR.     CAP."
IF(S2 .EQ. "YES" .OR. S2 .EQ. "Y")DISPLAY "     ********   *******"
DISPLAY " "
IF(S2 .EQ. "YES" .OR. S2 .EQ. "Y") GO TO 47
IF(S2 .EQ. "NO" .OR. S2 .EQ. "N") GO TO 45
IF(S2 .NE. "YES" .OR. S2 .NE. "Y") DISPLAY "PLEASE ENTER YES OR NO,YOU
**CAN ALSO ENTER Y OR N "
IF(S1 .NE. "YES" .OR. S1 .NE. "Y") GO TO 46
22 CONTINUE
47 DO 55 I= 1,101,5
REAL J,K,L,M,N
J=I-1
P=A1(1)
Q=D1(1)
V=A2(1)
S=D2(1)
T=P/(P+Q)
J=J/100
```

```
IF(J .LT. T)GO TO 13
W=P/J
J=J*100
GO TO 66
13  J=J*100
27  IF(V .EQ. 0 .AND. S .EQ. 0)DISPLAY "FOR "J" PERCENT ARR.YOU NEED AR
**R.& DEPT.CAP.OF REVISED R/W "
IF(V .EQ. 0 .AND. S .EQ. 0) GO TO 55
28  U=V/(V+S)
J=J/100
IF(J .LT. U)GO TO 29
K=V+S
L=P+Q
M=P-V
N=((V+S)*J-V)/(M+(K-L)*J)
W=L*N+K*(1-N)
J=J*100
GO TO 66
29  W=S/(1-J)
J=J*100
66  WRITE(1,300) J,W
 300  FORMAT(5X,I8,7X,I8)
55  CONTINUE
45  ACCEPT "DO YOU WANT TO MAKE ANOTHER CALCULATION?   ",S1
A1(I)=0
A2(I)=0
D1(I)=0
D2(I)=0
IF(S1 .EQ. "YES" .OR. S1 .EQ. "Y") GO TO 77
IF(S1 .EQ. "NO" .OR. S1 .EQ. "N") GO TO 80
IF(S1 .NE. "YES" .OR. S1 .NE. "Y") DISPLAY "PLEASE ENTER  YES  OR  NO
**,YOU CAN ALSO ENTER  Y  OR  N "
IF(S1 .NE. "YES" .OR. S1 .NE. "Y") GO TO 45
80  STOP
END
```

BASIC MODEL	REVISED VFR MODEL	REVISED IFR MODEL	BASIC MODEL	REVISED VFR MODEL	REVISED IFR MODEL
1-3	1-2	1-2			
			4-13	4-21	4-21
2-4	2-2	2-2	4-15	4-21	4-21
2-6	2-3	2-3	4-17	4-21	4-21
2-10	2-8	2-8	4-19	4-24	4-24
2-11	2-9	2-9			
2-12	2-9	2-9	5-2	1-2	1-2
2-17	2-15	2-15	5-3	5-1	5-1
2-18	2-15	2-15	5-4	1-2	1-2
2-20	1-2	1-2	5-5	5-4	1-2
2-22	2-20	1-2			
2-23	2-21	2-21	6-2	1-2	1-2
2-24	2-21	2-21	6-3	1-2	1-2
3-1	3-28	3-28	7-4	1-2	1-2
3-2	3-29	3-29	7-5	2-21	2-21
3-3	3-29	3-29	7-6	2-9	2-9
3-4	3-22	2-20			
3-5	3-23	2-20	10-1	10-5	5-1
3-6	3-24	3-24	10-2	3-29	2-15
3-7	3-22	2-21	10-3	3-22	2-21
3-8	3-22	2-21	10-4	3-22	2-21
3-9	3-23	2-20			
3-10	3-24	3-24	11-1	2-21	2-21
3-11	3-26	2-3	11-2	4-24	2-15
3-13	3-26	3-26	11-3	2-21	2-21
3-14	3-27	3-27	11-4	2-21	2-21
3-16	1-2	1-2			
3-17	1-2	1-2	12-1	1-2	1-2
3-18	3-25	2-15	12-2	2-9	2-15
3-19	3-25	2-15	12-3	1-2	1-2
3-20	3-22	2-21	12-4	12-3	1-2
3-21	3-22	2-21			
			13-1	3-26	2-15
4-1	2-3	2-3	13-2	3-29	3-29
4-3	2-9	2-9	13-3	3-22	2-21
4-5	4-22	4-22	13-4	3-22	2-21
4-7	4-21	4-21			
4-9	4-23	4-23	14-1	2-21	2-21
4-10	4-23	4-23	14-2	4-24	2-15
4-11	4-2	2-3			
			15-1	2-21	2-21
			15-2	2-21	2-21

FIGURE A-1

BASIC & REVISED RUNWAY USE
CONFIGURATIONS FOR PERCENT ARRIVAL TECHNIQUE

COMPUTER DIALOGUE FOR EXAMPLE 1
FIGURE A-[illegible]

```
execute pa.sfo
LOADING
EXECUTION


            ****** PERCENT ARRIVALS TECHNIQUE ******
                   FOR ALL R/W CAPACITY MODELS


ENTER DESIRED % ARRIVALS:    45
ENTER ARRIVAL CAPACITY OF BASIC RUNWAY USE CONFIGURATION:   35
ENTER DEPARTURE CAPACITY OF BASIC RUNWAY USE CONFIGURATION:   15

ENTER ARRIVAL CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL STRE
AMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:   0

ENTER DEPARTURE CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL ST
REAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:   55

PROPORTION OF TIME BASIC RUNWAY USE APPLIES =        .6644295
PROPORTION OF TIME REVISED RUNWAY USE APPLIES =      .3355705


                          (OPTION  1)
             *******************************************


             CAPACITY  =       51     OPERATIONS PER HOUR


DO YOU WANT A SENSITIVITY ANALYSIS OF PERCENT ARRIVALS TO CAPACITY?   y


     % ARR.      CAP.
    ********    ******

        0          55
        5          55
       10          54
       15          54
       20          53
       25          53
```

```
      30          53
      35          52
      40          52
      45          52
      50          51
      55          51
      60          51
      65          50
      70          50
      75          47
      80          44
      85          41
      90          39
      95          37
     100          35
DO YOU WANT TO MAKE ANOTHER CALCULATION?   n
STOP
```

FIGURE A-2 (Cont.)

```
execute pa.sfo
LOADING     -
EXECUTION



            ****** PERCENT ARRIVALS TECHNIQUE ******
                   FOR ALL R/W CAPACITY MODELS


ENTER DESIRED % ARRIVALS:   50
ENTER ARRIVAL CAPACITY OF BASIC RUNWAY USE CONFIGURATION:   70
ENTER DEPARTURE CAPACITY OF BASIC RUNWAY USE CONFIGURATION:   30

ENTER ARRIVAL CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL STRE
AMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:   0

ENTER DEPARTURE CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL ST
REAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:   110

PROPORTION OF TIME BASIC RUNWAY USE APPLIES =       .7333333
PROPORTION OF TIME REVISED RUNWAY USE APPLIES =     .2666667


                           (OPTION  1)
             *******************************************



             CAPACITY  =      102   OPERATIONS PER HOUR



DO YOU WANT A SENSITIVITY ANALYSIS OF PERCENT ARRIVALS TO CAPACITY?   n



DO YOU WANT TO MAKE ANOTHER CALCULATION?   n
STOP
```

COMPUTER DIALOGUE FOR EXAMPLE 2

FIGURE 7-3

```
 execute pa.sfo
LOADING
EXECUTION



          ****** PERCENT ARRIVALS TECHNIQUE ******
                 FOR ALL R/W CAPACITY MODELS


ENTER DESIRED % ARRIVALS:   50
ENTER ARRIVAL CAPACITY OF BASIC RUNWAY USE CONFIGURATION:   35
ENTER DEPARTURE CAPACITY OF BASIC RUNWAY USE CONFIGURATION:   25

ENTER ARRIVAL CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL STRE
AMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:   0

ENTER DEPARTURE CAPACITY OF REVISED RUNWAY USE CONFIGURATION WITH ALL ARRIVAL ST
REAMS ELIMINATED THAT COULD INFLUENCE DEPARTURE STREAMS:   70

PROPORTION OF TIME BASIC RUNWAY USE APPLIES =       .875
PROPORTION OF TIME REVISED RUNWAY USE APPLIES =     .125


                           (OPTION  1)
          *******************************************


          CAPACITY  =       61     OPERATIONS PER HOUR


DO YOU WANT A SENSITIVITY ANALYSIS OF PERCENT ARRIVALS TO CAPACITY?   n


DO YOU WANT TO MAKE ANOTHER CALCULATION?   n
STOP
```

COMPUTER DIALOGUE FOR EXAMPLE 3

FIGURE A-4

B.1 Introduction

This appendix presents two utility on-line programs that are useful for preparing inputs to the Runway Capacity Model and interpreting inputs used with the Runway Capacity Model. One program will convert observed average separations (i.e., AASR) over the threshold to the model input of minimum separation (i.e., DLTAIJ). The other program will convert the model input of minimum separation into an average separation over the threshold.

Copies of these utility programs are not available for distribution. A listing of each program is contained in paragraph B.6.

B.2 Model Logic

The value of average separation over threshold is related to minimum separation by the equation:

$$AASR(ij) = \frac{DLTA(ij)}{V(j)} - (SIGMA \times fPV) + MAX\left(0, G(j) \times \left(\frac{1}{V(j)} - \frac{1}{V(i)}\right)\right)$$

where:

AASR(ij) is the average separation between a pair of arrival aircraft over the threshold.

DLTA(ij) is the input DLTAIJ to the Runway Capacity Model; i.e., the minimum separation over the common approach path between a pair of arrival aircraft.

V(j) is the velocity of the trailing arrival aircraft.
V(i) is the velocity of the lead arrival aircraft.
SIGMA is the standard deviation of arrival-arrival separation.
fPV is the number of standard deviations to be applied to the standard deviation to create a separation buffer which will prevent aircraft from coming closer together than the minimum separation. NOTE: For probabilities less than .50, fPV will be a negative number.
G(j) is the length of the common approach path for the trailing aircraft.

B.3 Input Format

B.3.1 AASR to DLTA

The program to convert average separations over threshold into model inputs DLTAIJ can be called by the command EXECUTE DLTAIJ.SFO. The model will first ask for the average separation between each aircraft pair in nautical miles; i.e.,

```
D(A,A) =
D(A,B) =
D(A,C) =
D(A,D) =
D(B,A) =
D(B,B) =
D(B,C) =
D(B,D) =
D(C,A) =
D(C,B) =
D(C,C) =
D(C,D) =
D(D,A) =
D(D,B) =
D(D,C) =
D(D,D) =
```

After all separations have been input, the model will request values for the length of the common approach path in nautical miles by aircraft class; i.e.,

```
G(A) =
G(B) =
G(C) =
G(D) =
```

After all distances have been input, the model will request the standard deviation of arrival-arrival separation in seconds; i.e.,

```
SIGMA  ARR-ARR =
```

Followed by the absolute number of standard deviations you wish to include in the separation buffer; i.e.,

```
F(PROB. OF VIOLATION) =
```

Values of F(PROB. OF VIOLATION) are:

PROB. OF VIOLATION	F(PROB. OF VIOLATION)
.01	-2.35
.02	-2.05
.03	-1.90

.04	-1.75
.05	-1.65
.06	-1.55
.07	-1.45
.08	-1.40
.09	-1.35
.10	-1.30

B.3.2 DLTA to AASR

The program to convert the model input DLTAIJ into the average separation over theshold can be called by the command EXECUTE AASR.SFO. The model will ask the same series of questions shown in paragraph B.3.1. However, the input for D(A,A) through D(D,D) should be the value of DLTAIJ in nautical miles.

B.4 Output

The output of these models is a table listing the values of AASR and DLTAIJ for each aircraft pair.

B.5 Examples

The following example illustrates the use of AASR.SFO and DLTAIJ.SFO.

Example 1

Convert the following matrix of DLTAIJ values to AASR values:

		Trail Aircraft			
		A	B	C	D
Lead Aircraft	A	3	3	3	3
	B	3	3	3	3
	C	4	4	3	3
	D	6	6	5	4

The length of the common approach path is 6 nautical miles for all aircraft classes, SIGMA is 15 seconds and FPV = -1.9.

The computer dialogue for this problem is shown in Figure B-1. The matrix of AASR values is:

		Trail Aircraft			
		A	B	C	D
Lead Aircraft	A	3.8	4.0	4.0	4.1
	B	5.0	4.0	4.0	4.1
	C	6.4	5.4	4.0	4.1
	D	8.7	7.8	6.5	5.1

Example 2

Convert the following matrix of AASR values to DLTAIJ values.

		Trail Aircraft A	B	C	D
Lead Aircraft	A	3	3	3	3
	B	3	3	3	3
	C	4	4	3	3
	D	6	6	5	4

The length of the common approach path is 6 nautical miles for all aircraft classes, SIGMA is 15 seconds, and FPV = -1.9.

The computer dialogue for this problem is shown in Figure B-2. The matrix of DLTAIJ values is:

		Trail Aircraft A	B	C	D
Lead Aircraft	A	2.2	2.1	2.0	1.9
	B	1.0	2.1	2.0	1.9
	C	1.6	2.6	2.0	1.9
	D	3.3	4.2	3.5	2.9

B.6 PROGRAM LISTING

```
type aasr.sfo
DISPLAY'D=AASR,   G=GAMA'
DIMENSION G(4),DIJ(4,4)
REAL IAS
DISPLAY'TO CONVERT AASR INTO DLTAIJ'
ACCEPT 'D(A,A)=',DIJ(1,1),'D(A,B)=',DIJ(1,2),'D(A,C)=',DIJ(1,3),
                                                              'D(A,D)=
',DIJ(1,4)
ACCEPT'D(B,A)=',DIJ(2,1),'D(B,B)=',DIJ(2,2),'D(B,C)=',DIJ(2,3),
                                                              'D(B,D)='
,DIJ(2,4)
ACCEPT'D(C,A)=',DIJ(3,1),'D(C,B)=',DIJ(3,2),'D(C,C)=',DIJ(3,3),
                                                              'D(C,D)='
,DIJ(3,4)
ACCEPT'D(D,A)=',DIJ(4,1),'D(D,B)=',DIJ(4,2),'D(D,C)=',DIJ(4,3),
                                                              'D(D,D)='
,DIJ(4,4)
ACCEPT'G(A)=',G(1),'G(B)=',G(2),'G(C)=',G(3),'G(D)=',G(4)
ACCEPT 'SIGMA ARR-ARR=',SAA
ACCEPT'F( PROB. OF VIOLATION)=',FPV
DISPLAY'........................'
96 CONTINUE
97 CONTINUE
98 CONTINUE
DISPLAY 'A=1, B=2, C=3, D=4'
DISPLAY 'M=LEAD AIRCRAFT'
DISPLAY'N= TRAILING AIRCRAFT'
DO 100 M=1,4,1
IF (M.EQ.1)VI=95
IF(M.EQ.2)VI=120
IF(M.EQ.3) VI=130
IF(M.EQ.4) VI=140
15 DO 100 N=1,4,1
IF(N.EQ.1)VJ=95
IF (N.EQ.2)VJ=120
IF(N.EQ.3) VJ=130
IF(N.EQ.4) VJ=140
5 IF(VI.GT.VJ) GOTO 10
GOTO 20
DISPLAY'DDIJ MEANS DLTAIJ.  DIJ IS USED HERE FOR IAS.'
10 DDIJ=DIJ(M,N)+(((G(N)/VI)-(SAA*FPV/3600))*VJ)-G(N)
GOTO 30
20 DDIJ=DIJ(M,N)-(SAA*FPV*VJ/3600)
30 DISPLAY 'M=',M,'N=',N,'FOR AASR=',DIJ(M,N),'DLTAIJ IN N MI=',DDIJ
100 CONTINUE
END
```

```
type dltaij.sfo
DISPLAY'D=DLTAIJ,  G=GAMA,  '
DIMENSION G(4),DIJ(4,4)
REAL IAS
DISPLAY'TO CONVERT DLTAIJ INTO AASR IN N MI.'
ACCEPT 'D(A,A)=',DIJ(1,1),'D(A,B)=',DIJ(1,2),'D(A,C)=',DIJ(1,3),
                                                                'D(A,D)=
',DIJ(1,4)
ACCEPT'D(B,A)=',DIJ(2,1),'D(B,B)=',DIJ(2,2),'D(B,C)=',DIJ(2,3),
                                                                'D(B,D)='
,DIJ(2,4)
ACCEPT'D(C,A)=',DIJ(3,1),'D(C,B)=',DIJ(3,2),'D(C,C)=',DIJ(3,3),
                                                                'D(C,D)='
,DIJ(3,4)
ACCEPT'D(D,A)=',DIJ(4,1),'D(D,B)=',DIJ(4,2),'D(D,C)=',DIJ(4,3),
                                                                'D(D,D)='
,DIJ(4,4)
ACCEPT'G(A)=',G(1),'G(B)=',G(2),'G(C)=',G(3),'G(D)=',G(4)
ACCEPT 'SIGMA ARR-ARR=',SAA
ACCEPT'F( PROB. OF VIOLATION)=',FPV
DISPLAY'.......................'
96 CONTINUE
97 CONTINUE
98 CONTINUE
DISPLAY 'A=1, B=2, C=3, D=4'
DISPLAY ' '
DISPLAY'M= LEAD AIRCRAFT.'
DISPLAY 'N=TRAILING AIRCRAFT.'
DISPLAY' '
DISPLAY 106
DO 100 M=1,4,1
IF (M.EQ.1)VI=95

IF(M.EQ.2) VI=120
IF(M.EQ.3) VI=130
IF(M.EQ.4) VI=140
15 DO 100 N=1,4,1
IF(N.EQ.1)VJ=95
IF (N.EQ.2)VJ=120
IF(N.EQ.3) VJ=130
IF(N.EQ.4) VJ=140
5 IF(VI.GT.VJ) GOTO 10
GOTO20
10 IAS=(((G(N)+DIJ(M,N))/VJ)-(G(N)/VI)+(SAA*FPV/3600))*VJ
GOTO 30
20 IAS=DIJ(M,N)+(SAA*FPV*VJ/3600)
30 DISPLAY'M=',M,'N='N,'FOR DLTAIJ=',DIJ(M,N),'AASR IN N MI=',IAS
100 CONTINUE
END
```

```
execute dltaij.sfo
SFORTRAN: DLTAIJ
LOADING
EXECUTION
D=DLTAIJ,  G=GAMA,
TO CONVERT DLTAIJ INTO AASR IN N MI.
D(A,A)=3
D(A,B)=3
D(A,C)=3
D(A,D)=3
D(B,A)=3
D(B,B)=3
D(B,C)=3
D(B,D)=3
D(C,A)=4
D(C,B)=4
D(C,C)=3
D(C,D)=3
D(D,A)=6
D(D,B)=6
D(D,C)=5
D(D,D)=4
G(A)=6
G(B)=6
G(C)=6
G(D)=6
SIGMA ARR-ARR=15
F( PROB. OF VIOLATION)=1.9
........................
A=1, B=2, C=3, D=4

M= LEAD AIRCRAFT.
N=TRAILING AIRCRAFT.

 106
M=     1     N=     1     FOR DLTAIJ=     3     AASR IN N MI=     3.752083
M=     1     N=     2     FOR DLTAIJ=     3     AASR IN N MI=     3.95
M=     1     N=     3     FOR DLTAIJ=     3     AASR IN N MI=     4.029167
M=     1     N=     4     FOR DLTAIJ=     3     AASR IN N MI=     4.108333
M=     2     N=     1     FOR DLTAIJ=     3     AASR IN N MI=     5.002083
M=     2     N=     2     FOR DLTAIJ=     3     AASR IN N MI=     3.95
M=     2     N=     3     FOR DLTAIJ=     3     AASR IN N MI=     4.029167
M=     2     N=     4     FOR DLTAIJ=     3     AASR IN N MI=     4.108333
M=     3     N=     1     FOR DLTAIJ=     4     AASR IN N MI=     6.367468
M=     3     N=     2     FOR DLTAIJ=     4     AASR IN N MI=     5.411538
M=     3     N=     3     FOR DLTAIJ=     3     AASR IN N MI=     4.029167
M=     3     N=     4     FOR DLTAIJ=     3     AASR IN N MI=     4.108333
M=     4     N=     1     FOR DLTAIJ=     6     AASR IN N MI=     8.680655
M=     4     N=     2     FOR DLTAIJ=     6     AASR IN N MI=     7.807143
M=     4     N=     3     FOR DLTAIJ=     5     AASR IN N MI=     6.457738
M=     4     N=     4     FOR DLTAIJ=     4     AASR IN N MI=     5.108333

EXIT
```

COMPUTER DIALOGUE FOR EXAMPLE 1

FIGURE B-1

```
execute aasr.sfo
SFORTRAN: AASR
LOADING
EXECUTION
D=AASR,   G=GAMA
TO CONVERT AASR INTO DLTAIJ
D(A,A)=3
D(A,B)=3
D(A,C)=3
D(A,D)=3
D(B,A)=3
D(B,B)=3
D(B,C)=3
D(B,D)=3
D(C,A)=4
D(C,B)=4
D(C,C)=3
D(C,D)=3
D(D,A)=6
D(D,B)=6
D(D,C)=5
D(D,D)=4
G(A)=6
G(B)=6
G(C)=6
G(D)=6
SIGMA ARR-ARR=15
F( PROB. OF VIOLATION)=1.9
........................
A=1, B=2, C=3, D=4
M=LEAD AIRCRAFT
N= TRAILING AIRCRAFT
M=   1   N=   1   FOR AASR=   3   DLTAIJ IN N MI=   2.247917
M=   1   N=   2   FOR AASR=   3   DLTAIJ IN N MI=   2.05
M=   1   N=   3   FOR AASR=   3   DLTAIJ IN N MI=   1.970833
M=   1   N=   4   FOR AASR=   3   DLTAIJ IN N MI=   1.891667
M=   2   N=   1   FOR AASR=   3   DLTAIJ IN N MI=   .9979167
M=   2   N=   2   FOR AASR=   3   DLTAIJ IN N MI=   2.05
M=   2   N=   3   FOR AASR=   3   DLTAIJ IN N MI=   1.970833
M=   2   N=   4   FOR AASR=   3   DLTAIJ IN N MI=   1.891667
M=   3   N=   1   FOR AASR=   4   DLTAIJ IN N MI=   1.632532
M=   3   N=   2   FOR AASR=   4   DLTAIJ IN N MI=   2.588462
M=   3   N=   3   FOR AASR=   3   DLTAIJ IN N MI=   1.970833
M=   3   N=   4   FOR AASR=   3   DLTAIJ IN N MI=   1.891667
M=   4   N=   1   FOR AASR=   6   DLTAIJ IN N MI=   3.319345
M=   4   N=   2   FOR AASR=   6   DLTAIJ IN N MI=   4.192857
M=   4   N=   3   FOR AASR=   5   DLTAIJ IN N MI=   3.542262
M=   4   N=   4   FOR AASR=   4   DLTAIJ IN N MI=   2.891667
```

COMPUTER DIALOGUE FOR EXAMPLE 2

FIGURE B-2

APPENDIX C - DELAY FACTOR MODEL

C.1 Introduction

Reference b presents a graphic technique for determining average delay per operation. The technique employs delay indices, ADI and DDI, as well as delay factors, ADF and DDF. The values of ADI and DDI are a function of the parameter values (especially arrival-arrival separation) used to generate runway capacity and the demand on the runway.

This appendix describes the use of an on-line program to calculate ADI, DDI, ADF, and DDF. Copies of this program are not available for distribution. A listing of the program is contained in paragraph D.6. The model is currently available on TYMSHARE.

C.2 Model Logic

The equations used to calculate ADI, DDI, ADF, and DDF are defined in reference c on page IV-79 through IV-83.

C.3 Input Format

The on-line program to compute delay factors can be executed via the command EXECUTE DF.SFO. The input questions are:

```
ARRIVAL DEMAND=
DEPARTURE DEMAND=

HOURLY CAPACITY=
WHEN PERCENT ARRIVALS=

WHEN 9999 IS ENTERED FOR PERCENT ARRIVAL
ARRIVAL CAPACITY=
DEPARTURE CAPACITY=

FOR THE REVISED RUNWAY USE CONFIGURATION
ARRIVAL CAPACITY=
DEPARTURE CAPACITY=
```

NOTE: The percent arrival used to calculate HOURLY CAPACITY must be the same as that implied by the values of ARRIVAL DEMAND and DEPARTURE DEMAND.

C.4 Output

The output of this on-line program is:

ADI
ADF
DDI
DDF

This program can also produce a sensitivity analysis of delay factors to demand. After the first output is printed, the program asks:

DO YOU WANT A SENSITIVITY ANALYSIS OF ADI AND DDI TO D/C?

If a Y or YES is entered, the model will produce the following table:

DEMAND	D/C	ADI	DDI	ADF	DDF
	.05				
	.10				
	.				
	.				
	.				
	1.0				
	.				
	.				
	.				
	1.5				

The next question is:

DO YOU WANT TO CONSIDER ANOTHER DEMAND?

If a Y or YES is entered, the program will request:

ARRIVAL DEMAND=
DEPARTURE DEMAND=

If a N or NO is entered, the next question will be:

DO YOU WANT TO MAKE ANOTHER CALCULATION?

If a Y or YES is entered, the entire sequence of questions starting with ARRIVAL DEMAND= will be repeated. If a N or NO is entered, the run will terminate.

C.5 Example

The following illustrates the use of the on-line delay factor program.

Example 1

Compute ADF and DDF as well as the sensitivity of ADI and DDI to different demand levels for the following conditions:

Demand = 50 operations/hour
Capacity = 60 operations/hour at 50% arrival
Capacity for 9999 percent arrivals:
ARRIVAL 35
DEPARTURE 15
Capacity for the revised runway use configuration:
Arrival = 0
Departure = 60

The computer dialogue for this problem is shown in Figure D-1. For the given conditions:

ADF = .77
DDF = .83

The sensitivity of ADI and DDI to demand is:

Demand	ADI	DDI
6	.86	.53
12	.86	.57
18	.86	.62
24	.86	.67
30	.86	.74
36	.86	.81
42	.86	.91
48	.88	1.0
54	.99	1.0
60	1.0	1.0

C.6 Program Listing

```
type df.sfo
DISPLAY' '
DISPLAY' '
DISPLAY 'ON LINE PROGRAM TO CALCULATE DELAY FACTORS'
DISPLAY' '
DISPLAY' '
STRING Q1(3),Q2(3),Q3(3)
N=0
Y=0
Q3='N'
10 N=N+1
IF(Q3.EQ.'N') GOTO 20
Y=Y+0.10
IF(Y.GT.1.51) GOTO 400
D=Y*CX
DA=D*X
DD=D*(1.0-X)
GOTO 30
20 ACCEPT'ARRIVAL DEMAND=',DA,'DEPARTURE DEMAND=',DD
DISPLAY' '
IF(N.GT.1) GOTO 30
ACCEPT'HOURLY CAPACITY=',CX,'WHEN PERCENT ARRIVALS =',X
X=X/100.0
DISPLAY ' '
DISPLAY 'WHEN 9999 IS ENTERED FOR PERCENT ARRIVAL'
ACCEPT'ARRIVAL CAPACITY=',CUA,'DEPARTURE CAPACITY=',CUD
DISPLAY ' '
DISPLAY'FOR THE REVISED RUNWAY USE CONFIGURATION'
ACCEPT'ARRIVAL CAPACITY=',CUAP,'DEPARTURE CAPACITY=',CUDP
DISPLAY ' '
DISPLAY'**************************************************************'
DISPLAY ' '
30 D=DA+DD
CU=CUA+CUD
CUP=CUAP+CUDP
U=CUA/CU
UP=CUAP/CUP
CO=(1-UP)*CUP
R1=(X*D)/(U*CU)
CD1=(R1*(1-U)*CU)+((1-R1)*CO)
CA=CUA
R3=D/CX
R2=DA/CA
IF(R2.GT.1.0) GOTO 200
DDI=((1-X)*CX)/CD1
IF(DDI.GT.1.0) GOTO 105
ADI=(X*CX)/(U*CU)
IF (ADI.GT.1.0) ADI=1.0
GOTO 300
105 Q=((1-X)*CX-CO)/((DA/CA)*((1-U)*CU-CO))
110 ADI=(X*CX)/(Q*U*CU+(1-Q)*UP*CUP)
IF(ADI.GT.1.0) ADI=1.0
DDI=1.0
GOTO 300
200 IF(CU.GT.CX) GOTO 210
```

```
DDI=1.0
ADI=1.0
GOTO 300
210 IF(U.GE.X) GOTO 220
ADI=1.0
DDI=((1-X)*CX)/((1-U)*CU)
IF(DDI.GT.1.0) DDI=1.0
GOTO 300
220 IF((1-U)*CU.EQ.CO) GOTO 230
DDI=1.0
ADI=1.0
GOTO 300
 230 ADI=(X*CX)/(U*CU)
DDI=1.0
GOTO 300
300 CONTINUE
ADF=ADI*R3
DDF=DDI*R3
IF(Q3.EQ.'Y'.OR.Q3.EQ.'YES') GOTO 420
DISPLAY'ADI=',ADI,'     ADF='ADI*R3
DISPLAY 'DDI=',DDI,'     DDF='DDI*R3
GOTO 430
420 WRITE(1,500) D,R3,ADI,DDI,ADF,DDF
500 FORMAT(F6.1,5X,F3.1,3X,F6.4,5X,F6.4,4X,F6.4,4X,F6.4)
IF(Q3.EQ.'Y'.OR.Q3.EQ.'YES') GOTO 10
430 ACCEPT'DO YOU WANT A SENSITIVITY ANALYSIS OF ADI AND DDI TO D/C?',Q3
DISPLAY "  "
IF (Q3.EQ.'Y'.OR.Q3.EQ.'YES') DISPLAY ' DEMAND     D/C      ADI          DDI
   ADF       DDF '
IF( Q3.EQ.'Y'.OR.Q3.EQ.'YES') GOTO 10
 400 ACCEPT'DO YOU WANT TO CONSIDER ANOTHER DEMAND?',Q1
Q3='N'
Y=0
IF(Q1.EQ.'Y'.OR.Q1.EQ.'YES') GOTO 10
ACCEPT'DO YOU WANT TO MAKE ANOTHER CALCULATION?',Q2
IF (Q2.EQ.'Y'.OR.Q2.EQ.'YES') N=1
IF(Q2.EQ.'Y'.OR.Q2.EQ.'YES') GOTO 20
END
```

```
 execute df.sfo
LOADING
EXECUTION

ON LINE PROGRAM TO CALCULATE DELAY FACTORS

ARRIVAL DEMAND=25
DEPARTURE DEMAND=25

HOURLY CAPACITY=60
WHEN PERCENT ARRIVALS =50

WHEN 9999 IS ENTERED FOR PERCENT ARRIVAL
ARRIVAL CAPACITY=35
DEPARTURE CAPACITY=15

FOR THE REVISED RUNWAY USE CONFIGURATION
ARRIVAL CAPACITY=0
DEPARTURE CAPACITY=60

******************************************************************

ADI=    .9183673        ADF=      .7653061
DDI=    1           DDF=      .8333333
DO YOU WANT A SENSITIVITY ANALYSIS OF ADI AND DDI TO D/C?y

  DEMAND     D/C     ADI          DDI        ADF       DDF
    6.0      .1     .8571        .5344      .0857     .0534
   12.0      .2     .8571        .5738      .1714     .1148
   18.0      .3     .8571        .6195      .2571     .1858
   24.0      .4     .8571        .6731      .3429     .2692
   30.0      .5     .8571        .7368      .4286     .3684
   36.0      .6     .8571        .8140      .5143     .4834
   42.0      .7     .8571        .9091      .6000     .6364
   48.0      .8     .8816       1.0000      .7053     .8000
   54.0      .9     .9918       1.0000      .8927     .9000
   60.0     1.0    1.0000       1.0000     1.0000    1.0000
   66.0     1.1    1.0000       1.0000     1.1000    1.1000
   72.0     1.2    1.0000       1.0000     1.2000    1.2000
   78.0     1.3    1.0000       1.0000     1.3000    1.3000
   84.0     1.4    1.0000       1.0000     1.4000    1.4000
   90.0     1.5    1.0000       1.0000     1.5000    1.5000
DO YOU WANT TO CONSIDER ANOTHER DEMAND?n
DO YOU WANT TO MAKE ANOTHER CALCULATION?n

EXIT
```

COMPUTER DIALOGUE FOR EXAMPLE 1

FIGURE C-1

APPENDIX D

GLOSSARY

A	-	Arrivals.
A	-	First of four classes of aircraft (ABCD), usually small.
AA	-	A class A arrival followed by a class A arrival.
AB	-	A class A arrival followed by a class B arrival.
AC		A class A arrival followed by a class C arrival.
AD	-	A class A arrival followed by a class D arrival.
ADSR	-	Item 12 of the input file. Contains ADSR information required for certain non-parallel configurations.
ADSR(I,J,IRUM)	-	Arrival/departure separation requirement -- for intersecting runways, the minimum time after arrival I crosses the threshold at which departure J can be released.
ADSRX	-	A single value of ADSR which applies to all values of I and J.
ALPHA	-	Space available for comments on each header line of the input file.
ALTARR	-	Item 25 of the input file, containing information needed for alternating arrival operations.
APPSPD	-	Item 5 of the input file, containing approach speeds.
ARBAR(IRUM,I)	-	The average runway occupancy time of aircraft I on runway IRUM.
ARBAR2	-	Item 2 of the input file, containing arrival runway occupancy data.
ATC	-	Air Traffic Control.

B	-	Second of four aircraft classes (ABCD), usually either small or large (assumed large by on-line version of the Capacity Model).
B	-	Both arrivals and departures on the same runway -- mixed operations.
BA	-	A class B arrival followed by a class A arrival.
BAA	-	Item 24 of the input file, containing data for close-spaced parallel approaches.
BAA(I,J)	-	Buffer time between consecutive arrivals to separate close-parallel runways to prevent a heavy aircraft from overtaking a slower non-heavy aircraft.
BB	-	A class B arrival followed by a class B arrival.
BC	-	A class B arrival followed by a class C arrival.
BD	-	A class B arrival followed by a class D arrival.
BDD	-	Item 22 of the input file, containing data for close-spaced parallel departures.
BDD(I,J)	-	Buffer time between consecutive departures on separate close-spaced parallel runways.
C	-	Close-spaced parallel runways (700-2499 feet apart).
C	-	Third of four aircraft classes (ABCD), usually large.
CA	-	A class C arrival followed by a class A arrival.
CB	-	A class C arrival followed by a class B arrival.
CC	-	A class C arrival followed by a class C arrival.
cc	-	Card column.
CD	-	A class C arrival followed by a class D arrival.
CDC	-	Control Data Corporation.
CEILNG	-	Weather ceiling, in feet.

CLDIST	-	Distance between centerlines of two parallel runways.
CNV	-	Convergence criterion used in f.e.d. mix calculations.
D	-	Last of four aircraft classes (ABCD), usually heavy.
DA	-	A class D arrival followed by a class A arrival.
DB	-	A class D arrival followed by a class B arrival.
DC	-	A class D arrival followed by a class C arrival.
DD	-	A class D arrival followed by a class D arrival.
DDSR(I,J)	-	Departure/departure separation requirement -- minimum time between departures I and J, in seconds.
DELIAT	-	The incremental time (in seconds) by which arrival gaps are stretched.
DIAGSP	-	The diagonal separation required between alternating arrivals on separate runways.
DICBR	-	Item 13 of the input file. Contains DICBR information needed for some non-parallel configurations.
DICBR(I,J)	-	On intersecting runways, the minimum distance arrival J can be from the threshold when departure I is released.
DICBRX	-	A single value of DICBR which applies to all values of I and J.
DLTADA	-	The minimum distance an arrival must be from the threshold in order to release a departure on the same or close-parallel runway.
DLTAIJ	-	Item 4 in the input file, containing interarrival separations.
DLTAIJ(I,J)	-	The minimum airborne separation required between lead aircraft I and trail aircraft J.
DRBAR	-	Item 6 in the input file, containing departure runway occupancy times.

DRBAR(I)	-	Average departure runway occupancy time for class I
DV	-	Diverging; refers to operations on non-parallel, non-intersecting runways.
F	-	Future ATC system, standard set of parameter values.
F	-	Far-spaced parallel runways (more than 4300 feet apart).
FAA	-	Federal Aviation Administration.
f.e.d.	-	First enqueued departure -- refers to the probability that a particular aircraft type will be the first in line to depart, as different from the overall proportion of that type in the fleet.
GA	-	General aviation.
GAMA	-	Item 9 in the input file, containing final approach path lengths.
GAMA(I)	-	The final approach path length for class I.
GSLOPE	-	Glide slope angle.
GTDISP	-	The relative displacement of the final approach gates, used for alternating arrivals.
I	-	Typically, the lead aircraft in the current arrival pair IJ.
IALT	-	Flag which indicates whether or not alternating arrivals are to be modeled.
IAX	-	Flag used to indicate whether aircraft are airborne at the runway intersection.
IFR	-	Instrument Flight Rules
IMC	-	Instrument Meteorological Conditions.
IMODEL	-	The model series of the configuration being analyzed.
INCIAT	-	Item 26 of the input file, containing data for the first-enqueued departure and gap-stretching options.

INDEX	-	The number of each item in the data file. Located on the header line, it informs the program what data is contained on the next line.
INST	-	The number of intermediate points to calculate, plus one (for arrival-priority point).
IPA	-	The arrival percentage(s) at which capacity is to be calculated.
IR	-	Flag which indicates the degree of dependence between two non-parallel, non-intersecting runways.
IRUM	-	The number (1-4) of the runway to which the following data pertains. Required for RUNWAY (item 1), ARBAR2 (item 2), and ADSR (item 12).
ISTRGY	-	The original operating strategy of the configuration being analyzed.
J	-	Typically, the trail aircraft in the current arrival pair IJ.
JBOMB	-	The maximum number of iterations to be performed by the f.e.d. mix logic.
K	-	Typically, the first departure in the IJ gap.
M	-	Medium-spaced parallel runways -- originally 3500-4299 feet apart, but currently 2500-4299 feet apart.
max	-	maximum.
min	-	minimum
MMC	-	Marginal Meteorological Conditions.
N	-	Near-spaced parallel runways (2500-3499 feet apart) -- not a separate operational category today.
NAME	-	On each header line in the input file, the arbitrary title for each data item.
NCARD	-	A flag which indicates the final data item for each capacity calculation (not necessarily the final data item in the input file).
NEWRUN	-	Item 0 of the input file, containing values of IMODEL, ISTRGY, and IALT.

OPENV - Line 10 of the input file, containing information needed for non-parallel, non-intersecting runway configurations.

OPENVX - The distance between the thresholds of two open-V runways.

OTHERS - Item 20 of the input file containing miscellaneous data.

P - Present ATC system, standard set of parameter values.

PFED(I,J) - The probability that departure K is the first enqueued departure after arrival I.

PHR(K) - The proportion of type K in the overall fleet mix.

POTG - The percentage of touch-and-go operations.

PV - The probability of violation for all stochastic variables in the program (arrival R.O.T., etc.) except interarrival time.

PVI - The probability of violation for the interarrival separation. The average separation is such that only this proportion of all separations is less than the minimum separation, DLTAIJ.

Q-logic - The program logic by which the possible effects of previous departures are accounted for.

RJE - Remote Job Entry -- batch processing of computer programs, using card decks.

R.O.T. - Runway Occupancy Time

RUNWAY - Item 1 of the input data file, containing aircraft fleet mix information.

SIGAI - The standard deviation of the time for an arrival to clear the runway intersection.

SIGDI - The standard deviation of the time for a departure to clear the runway intersection.

SIGMAA - The standard deviation of the interarrival time.

SIGMAC - The standard deviation of the time from departure clearance to start of roll.

SIGMAR - The standard deviation of the arrival runway occupancy time.

SIGMAS - Item 19 of the input file, containing standard deviation data.

SIGMDR - The standard deviation of departure runway occupancy time.

SIGTGR - The standard deviation of touch-and-go runway occupancy times.

T & G - Touch-and-go -- landing aircraft takes off again immediately, without stopping.

TAA - The weighted average interarrival time for all aircraft pairs.

$\overline{TAA}(I,J)$ - The average interarrival between arrivals I and J.

TD - Item 7 of the input file, containing minimum departure-departure separations.

TDD - The weighted average interdeparture time for all aircraft pairs.

$\overline{TDD}(K,L)$ - The average interdeparture time between departures K and L.

TGRBAR - Item 9 of the input file, containing touch-and-go occupancy times.

TGRBAR(I) - The average touch-and-go occupancy time for class I arrivals.

THETA - The angle between non-parallel runways.

THDISP - For alternating arrivals, the relative displacement between runway thresholds.

TWOIN - Item 11 of the input file, containing information for certain intersecting runway configurations.

TXI(I,K)	-	The time from release to clearing the intersection for departure I on runway K.
V(I)	-	The final approach velocity of arrival I.
VFR	-	Visual Flight Rules.
VIS	-	Weather visibility, statute miles.
VMC	-	Visual Meteorological Conditions.
7777	-	Special value for arrival percentage (IPA), which causes the program to calculate and print the capacity for arrival priority, for the maximum number of intermediate points, and for departure priority.
8888	-	Special value for arrival percentage (IPA), which causes the program to calculate and print the capacity for arrival priority and for departure priority.
9999	-	Special value for arrival percentage (IPA), which causes the program to calculate and print the capacity for arrival priority only.

APPENDIX E

REFERENCES

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